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THE INSECTS AND ARACHNIDS OF CANADA

PART 2

The Bark Beetles of Canada and Alaska

Coleoptera: Scolytidae

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and Nematodes by J. E. H. Martin,
Canada Department of Agriculture, Ottawa,
is in preparation.

Frontispiece: *Upper* An elm tree infected with Dutch elm disease, at Ottawa, Ontario. The snags were killed several years previously. Dutch elm disease is transmitted by the smaller European elm bark beetle, *Scolytus multistriatus* (Marsham), and the native elm bark beetle. *Hylurgopinus rufipes* (Eichhoff). *Lower* Typical damage by the mountain pine beetle. *Dendroctonus ponderosae* Hopkins, in lodgepole pine, at Waterton Lakes National Park, Alberta.

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Introduction

Two hundred and fourteen species of Scolytidae known or suspected to occur in Canada and Alaska are dealt with in this publication. Also included are keys to genera and species, brief descriptions, distribution maps, and biological data. Photographs of whole and parts of beetles were taken with the aid of the scanning electron microscope. Conventional photographs show the gallery patterns.

This handbook has been prepared because of the increased interest and research activity into all aspects of scolytid biology, classification, distribution, and behavior.

The aim of this book is to assist students, amateurs, technicians, entomologists, and practicing foresters in identifying the various species of Scolytidae found in Canada and Alaska, to briefly review the known biological information, and to indicate where more detailed information can be found. All the species known or suspected to occur in Canada and Alaska are included. Host plants, gallery patterns, maps of Canadian and Alaskan distribution, and other details that might be helpful in identification are included when known.

The bark beetles are one of the most serious threats to northern forests. A few species in several genera are particularly destructive and have been chronic problems since the beginning of the lumbering industry. As the demand for forest products increases and the profitable forest acreage decreases, insect problems have become more important. Species that have been considered of only minor or no economic importance may suddenly become extremely important as our utilization of the forest intensifies. Therefore, careful and detailed studies of all aspects of scolytid biology and behavior are needed so that the injurious or potentially injurious species can be readily determined. The purpose of this book is to help promote such studies.

In 1918, Dr. J. M. Swaine published his classical work entitled *Canadian Bark Beetles*. This book was the first of the modern-day treatises in which the biology as well as the classification was stressed. Since 1918, the volume of literature dealing with the biology and classification of the Scolytidae has increased tremendously. Although Swaine's treatment is out-of-date, it still is one of the finest works available on the bark beetles of North America.

The first comprehensive review of the nearctic bark beetles was published in 1876 by LeConte and Horn; 127 species were recognized. Swaine (1918) in his *Canadian Bark Beetles* treated 213 species. Chamberlin (1939) collected all the scattered descriptions, revisions, and other taxonomic literature for *The bark and timber beetles of North America north of Mexico*, in which he dealt with about 550 species. Various regional works have been completed and published: Minnesota (Dodge 1938), North Carolina (Beal and Massey 1945), Pacific Northwest (Wood *in* Hatch 1971), and California (Bright and Stark 1973). Most of the important genera have been revised at least once since 1928.

General biology

For many years bark beetles have been considered to be the most destructive forest insects known. Each year, bark beetles are responsible for the loss of billions of board feet of timber worth millions of dollars. However, in recent years, it is believed that outbreaks of these pests have a necessary function in the evolution of forest stands. Infested timber, if salvaged promptly, loses little market value. In an undisturbed forest succession, bark beetles feed upon and kill the excess plants in the stand. It is only when such stands reach the climax stage and become decadent from a predominance of overmature trees that "natural" outbreaks occur. These outbreaks result in a release of the understory, and a new phase of succession begins again. The well-documented outbreak of the spruce beetle, *Dendroctonus engelmanni* Hopkins (now known as *rufipennis* (Kirby)), which destroyed 11.25 million m^3 (4.5 billion board feet) of spruce in Colorado between 1939 and 1953 and which was considered devastating at the time, is now viewed by many foresters as having had a beneficial effect in renewing an overaged forest (Borden 1971).

However, bark beetle outbreaks, which destroy vast supplies of timber that cannot be salvaged or absorbed into the economy, do occur; these outbreaks are real resource losses.

Outbreaks may occur naturally in mature and overmature forests initiated by such predisposing events as fire, windthrow, drought, or flooding, but most of them are, directly or indirectly, caused by man. Poor logging and management practices; urbanization; air, water, and soil pollution; and other abuses all predispose trees and forests to outbreaks of the bark beetle.

All members of Scolytidae, with few exceptions, feed and reproduce in the cambium region (true bark beetles) or deep in the wood (ambrosia beetles) of dying, injured, or fallen trees and shrubs. Most of the Canadian species attack forest trees, especially conifers. Other hosts, such as cones, roots of legumes, and woody shrubs provide breeding places for the few exceptions

All the woody parts of a tree are attacked, but the species of each genus usually restrict their activities to a particular portion. For example, the species of *Pityophthorus* and *Myeloborus* are found in the smaller branches and twigs; *Conophthorus* in the cones; *Ips* in the larger branches, bole, and tops; *Dendroctonus* in the bole and sometimes in the roots; and *Hylurgops* and *Hylastes* in the lower portions and roots. Species belonging to all these genera may be found in the various locations throughout a single pine tree.

After selecting a suitable location, usually under a bark scale, under moss or lichens, or in a bark crevice, the beetle bores a hole, generally at a slight upward angle, directly into the cambium region. The adult ambrosia beetle bores directly into the wood for several centimeters. The first evidence of attack is the appearance of reddish or whitish boring dust or pitch tubes under or around each entrance hole.

Both monogamy and polygamy are practiced, depending on the genus involved. In all known cases of polygamy, the male makes the initial attack and is subsequently joined by three to five or more females. In the monogamous species, the female makes the initial attack and is joined by the male. Mating

may take place in the gallery, on the surface of the host plant, or before the insects leave the host plant of the parents.

Females of true bark beetles tunnel away from the entrance hole in the cambium region and lay eggs singly or in groups along the gallery. The eggs may be laid in specially constructed niches along the gallery wall or scattered in the boring dust along the gallery. Females of the ambrosia beetles lay eggs scattered along the gallery or in niches. Adult galleries may be packed with frass and boring dust (e.g., *Dendroctonus* spp.) or kept clean (e.g., *Ips* spp.), the frass being pushed out through the entrance hole.

The larvae of true bark beetles usually mine at right angles to the parent gallery and may or may not engrave the sapwood. The larval mines may continue in a straight line or curve in various directions. Later instars usually mine with the grain of the wood. Larval mines are always packed with frass. Some species mine entirely in the inner bark and the larval mines are exposed when the bark is removed. Others may mine for a short time in the inner bark, then they complete their feeding in the outer bark, whereas other species feed entirely in the outer bark. The larval mines may be straight and very regular, or they may be very irregular and meandering. However, they rarely cross one another unless the beetles are crowded. In species that lay their eggs en masse in grooves or cavities, the larvae often extend their borings as a group, forming an enlarged chamber without distinct larval mines; or the mines may be contiguous at first, becoming separated in later instars. The larvae of ambrosia beetles feed in larval cradles constructed by the parent beetle.

Pupation takes place in enlarged cells at the end of the larval mines in the inner bark, the cambium region, the outer bark, or, in the case of ambrosia beetles, in the cradles or the open mines. Most emerging beetles exit individually, boring their own exit hole, which often results in characteristic patterns on the bark. Young adults of ambrosia beetles usually exit through the parental entrance galleries.

Galleries

A characteristic and most interesting part of scolytid biology is the adult egg gallery under the bark (Figs. 178–192). In uncrowded conditions, these galleries are often very symmetrical and interesting in appearance. The galleries may be so characteristic to the family that the genus or, in some cases, the species that made the gallery can be easily identified.

Several analyses of the gallery patterns have been published: Beal and Massey (1945); Chamberlin (1939, 1958); Swaine (1918); Traghardh (1930). All these authors used the same terminology in describing the various types of galleries.

Two types of galleries made by the ambrosia beetle can be found in Canadian forests: the cave type (*Xyleborus saxeseni*) and the compound tunnel (*Trypodendron*, Fig. 184; *Gnathotrichus* and *Monarthrum*, Fig. 192). All these tunnels are excavated in the wood. The cave type is simply an enlarged chamber, and the compound type is a branched tunnel that contains individual cells or cradles in which the larvae develop.

Seven types of galleries can be recognized in Canadian forests as the work of the true bark beetles. These are cave type (*Dendroctonus valens*); radiate or star-shaped type (species of *Ips*, Figs. 187, 188; *Pityophthorus*, Fig. 191; *Carphoborus*, *Dryocoetes*, *Orthotomicus*, and others); forked type (*Scolytus ventralis*, Fig. 178; *Alniphagus aspericollis;* various species of *Pseudohylesinus* and others); simple longitudinal or transverse (species of *Phloeosinus*, Figs. 182, 183; *Scolytus unispinosus; Dendroctonus ponderosae* and others); irregular elongate tunnels (*Dendroctonus brevicomis*, Fig. 179); pith tunnels (species of *Myeloborus* and *Pityophthorus*); and cone tunnels (species of *Conophthorus*, Fig. 189). These types have been described adequately by other authors and, therefore, are not repeated here.

Distribution

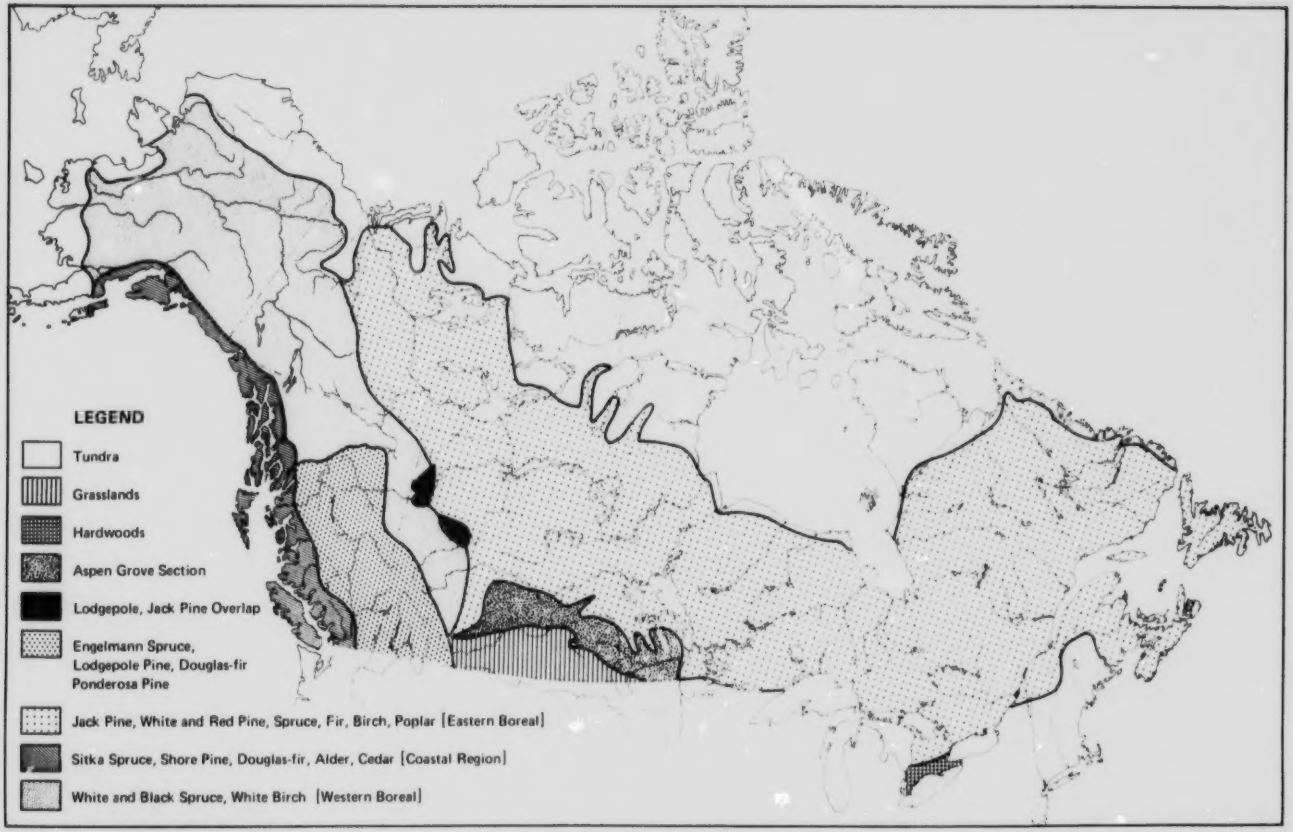
The Canadian bark beetles can be divided into four major categories based on distribution: transcontinental, western boreal or montane, eastern boreal, and southern (see Map 1).

The transcontinental category contains species found throughout the northern coniferous forest from Alaska to Newfoundland. Some representatives of this category are also found in the northern Palearctic forest (*Trypodendron lineatum*, *Dryocoetes autographus*, and others). Canadian examples with a transcontinental distribution are *Ips pini*, *Scolytus piceae*, *Polygraphus rufipennis*, *Crypturgus borealis*, *Dendroctonus rufipennis*, *Dendroctonus simplex*, *Dryocoetes affaber*, *Dryocoetes autographus*, *Orthotomicus caelatus*, and others. Many of these species are associated with *Picea* spp. and reflect the range of the various species in that genus of trees.

The western boreal or montane category contains species that are found west of the Rocky Mountains and in the Yukon Territory and Alaska. These species are mostly northern forms that may extend into Western United States at high elevations. Some examples are *Polygraphus convexifrons*, *Carphoborus andersoni*, *Carphoborus carri*, and others. Many other Western Canadian distributions are the northern extensions of a more widespread distribution in the United States and are referred to in the southern category. A distinct subdivision can be recognized in the coastal regions of British Columbia and southeastern Alaska. Characteristic species of this coastal region are *Dolurgus pumilus*, *Pseudohylesinus sitchensis*, and *Ips concinnus*.

The eastern boreal category contains species found east of the Rocky Mountains and parallels the range of *Pinus banksiana* or *Abies balsamea* from northern Alberta to Newfoundland. Examples of species with this distribution are *Gnathotrichus materiarius*, *Ips perroti*, *Pityokteines sparsus*, *Pityogenes hopkinsi*, *Pityophthorus pulchellus*, and others.

The fourth category, the southern, is more difficult to define. It contains species that are generally widespread in eastern or western United States but whose distribution just barely extends into southern British Columbia, into southern Ontario and southern Quebec, or into the southern portions of the Maritime Provinces. These species are associated with hosts such as *Pinus ponderosa*, *Quercus* spp., *Juniperus* spp., and others. Examples of species with this type of distribution are *Dendroctonus ponderosae*, *Dendroctonus*


LEGEND
Tundra
Grasslands
Hardwoods
Aspen Grove Section
Lodgepole, Jack Pine Overlap
Engelmann Spruce, Lodgepole Pine, Douglas-fir Ponderosa Pine
Jack Pine, White and Red Pine, Spruce, Fir, Birch, Poplar [Eastern Boreal]
Sitka Spruce, Shore Pine, Douglas-fir, Alder, Cedar [Coastal Region]
White and Black Spruce, White Birch [Western Boreal]

Map 1. Simplified forest classification of Canada and Alaska (adapted from Viereck and Little (1972) and Hosie (1969)).

brevicomis, *Dendroctonus pseudotsugae*, *Gnathotrichus retusus*, *Hylastes* spp., *Hylurgops subcostulatus*, *Ips plastographus*, *Ips calligraphus*, *Ips grandicollis*, *Phloeosinus canadensis*, and many others.

In Canada with its broad vegetation zones and lack of endemic species of potential scolytid host plants, it is not surprising that endemism is so poorly developed. Only one species, *Carphoborus andersoni*, may be considered endemic to Canada, and even this species may eventually be found in the high mountains of the western United States. Several species of *Pityophthorus* are known only from a few localities in Canada, but the distributions of most species in this genus are so poorly known that no judgment of their status can be made.

Morphology

This section does not give a complete treatment of scolytid morphology. Only terms used in the keys and descriptions are included (Figs. 1–4). The glossary at the back of this book defines the terms that are used throughout the book.

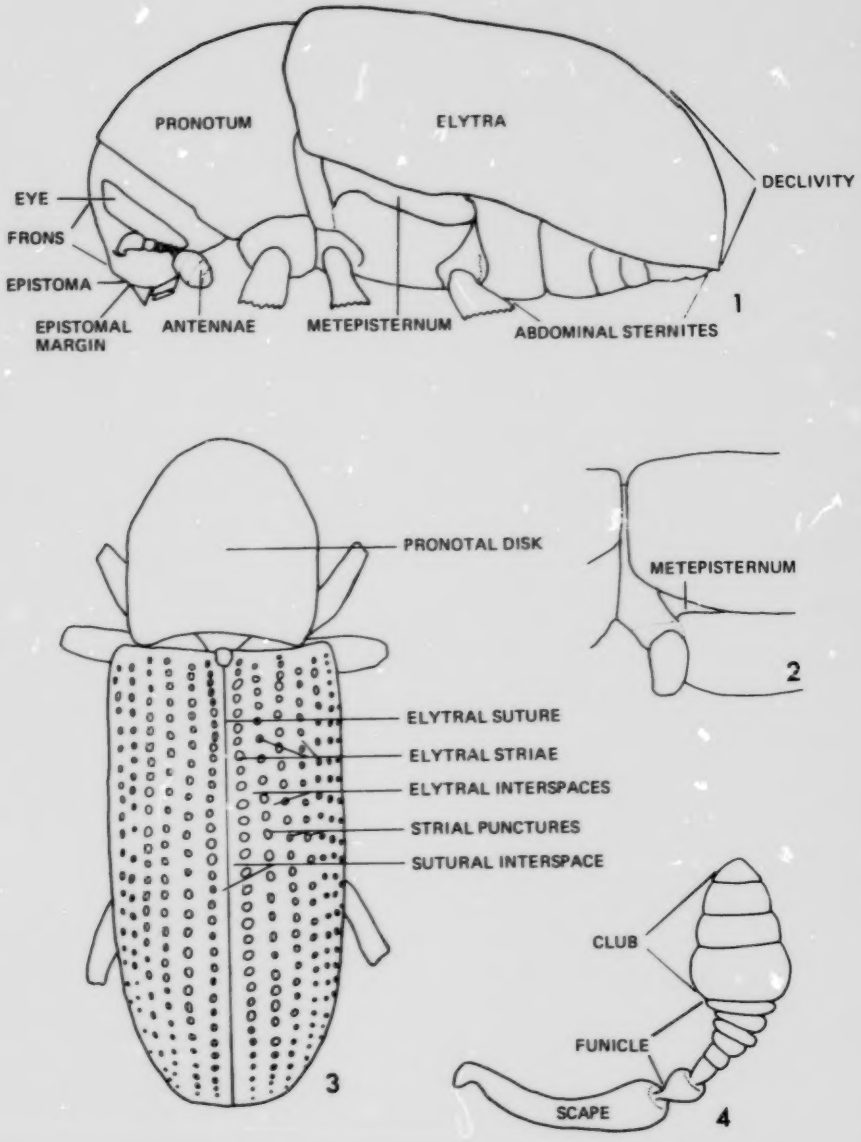
Head

Frons. The frons is not readily defined by visible lines or sutures but is used to distinguish the area between the eyes that extends to the epistoma. It may be concave or convex and is variously ornamented with punctures, carinae, setae, or other modifications. It is of special value in the classification of the scolytids because it presents characters useful in distinguishing major and minor divisions, species, and sexes.

Epistoma. The epistoma is represented in scolytids by a thickened, more heavily sclerotized region below the frons. It provides a rigid support for the articulation of the mouthparts. It, like the frons, may be ornamented with various structures. The epistomal process, seen in *Dendroctonus* spp. and several other genera, is on the upper margin of the epistoma. The median lobe, most prominent in *Dendroctonus* spp., is variably developed. The epistomal margin usually bears a fringe of stiff light-colored setae.

Eyes. The eyes are usually elongate-oval and are placed on the side of the head just posterior to the antennal insertions. In the adults of most species, a slight to deep emargination is present on the front margin of the eye. In *Trypodendron* spp. and *Polygraphus* spp., this emargination is so deep that it appears to completely divide the eye.

Antennae. The antennal regions are shown in Fig. 4. The scape is usually club-shaped, except in *Micracis* spp. (Fig. 74), in which it is roughly triangular. The funicle has 1–7 segments and is often used in classification. The club is extremely variable and is one of the most useful structures used in classification. It may be regularly segmented with transverse or arcuate sutures on both sides (*Pityophthorus* spp., Fig. 99); or the inner margins of the segments may be thrust toward or to the apex of the club so that the segments lie obliquely and the sutures are visible only at the apex or not at all on the inner face (*Ips* spp., Figs. 89–94); or the club may be thickened at the base with the apical segments more



Figs. 1–4. 1, Lateral view of *Hylastinus obscurus* showing various morphological terms. 2, Lateral view of metepisternal region of *Pityophthorus* sp. showing metepisterna concealed except for anterior portion. 3, Dorsal view of *Hylastes macer* showing various morphological terms. 4, Antennae of *Pseudohylesinus* sp. showing morphological regions.

or less telescoped producing the obliquely truncate club (species of *Xyleborus*, *Dryocoetes*, etc., Figs. 83, 84). In the species in the genera *Pseudopityophthorus* (Fig. 98), *Pityophthorus* (Fig. 99), and *Gnathotrichus* (Fig. 96), the sutures of the club are strongly chitinized, resulting in more or less distinctly visible septa. In *Chramesus* spp. (Fig. 70) the club is unsegmented.

Thorax

Pronotum. The pronotum is the dorsal area of the prothorax. There is considerable specific variation in the pronotal shape, sculpture, and relative proportions. The anterior margin may or may not bear serrations. A lateral line, or basal line, or both, may or may not be present. The disk is the central area of the pronotum and is the region most often used in classification.

Legs. The tibiae and tarsi offer several modifications that are important in classification (Figs. 55–59). A major character used in distinguishing the Scolytini from other scolytid tribes is the presence of a large curved spine on the upper apical angle (Fig. 56). The presence of elongate tarsal and tibial hairs is a secondary sexual character in some genera. The shape of the fore tibia is important in distinguishing the Xyleborini and Micracini from other tribes (Figs. 55, 58), and the presence of tubercles scattered over the outer face of the anterior tibia distinguishes the Corthylini from the Pityophthorini.

Elytra. The elytra are extremely variable in structure and sculpture. The elytral striae are usually punctured in rows; the spaces between the rows are the elytral interspaces. For use in classification the elytral interspaces are numbered, beginning with those next to the dorsal suture when the elytra are closed. The first interspace is sometimes called the sutural interspace. There are 11 interspaces and 10 striae. The interspaces are variable in width and sculpture, bearing interstrial punctures, setae, tubercles, and so on. The strial punctures are almost always visible, but they may be obsolete and may or may not be in regular rows. The elytral suture, the junction of the elytra along the dorsum, is often elevated by the convexities of the first or sutural interspace. The posterior portion of the elytra that descends to the apex is the elytral declivity. This area, and the antennal club, are the most important areas used in the classification of the Scolytidae. The declivity is usually steep, sometimes truncate or concave, and may be smooth and unarmed as in *Dryocoetes*, or may bear spines, teeth, tubercles, or special pubescence in all forms of variation imaginable. The declivity is absent in *Scolytus*.

Metepisternum. This is a plate in the shape of a narrow triangle with the base facing forward. It is completely visible (Fig. 1) in all genera except those in the tribes Pityophthorini and Corthylini (Fig. 2). In these two tribes, the elytra, when closed, extend ventrad to a greater degree than in other scolytids and cover at least the posterior two-thirds of the metepisternum.

Abdomen

The abdomen is not usually used in the classification of the Scolytidae except to distinguish the tribe Scolytini from the remainder of the scolytids. In the Scolytini, the elytra are nearly flat and the ventral sternites of the abdomen ascend to meet them. The five visible sternites vary in the degree of fusion,

length, and convexity. The last sternite may be modified in some genera. It is generally considered that the first two sternites are fused and hidden in the metacoxal cavities; in this publication, the five visible segments are numbered 1 to 5.

Methods

All species known or suspected to occur in Canada are included. For each species, the following information is given: synonyms (if any), a brief diagnosis emphasizing the most obvious or easily visible morphological features, host plants in Canada, a brief statement of geographic distribution, a detailed distribution map showing all known localities where the species has been found in Canada and Alaska, and a brief summary of the biology (if known) with references where additional information can be found.

The reference collections of the Canada Department of Agriculture and of the various forestry laboratories across Canada have served as the primary source of the distributional data. These data are summarized on the maps and in the text, but the complete data (locality, date, host, and collector) may be obtained from the author.

Common source references to the known biologies of many scolytids include Bright and Stark (1973), Chamberlin (1939, 1958, 1960), Keen (1952), Craighead (1949), Baker (1972), Graham and Knight (1965), Doane et al. (1936), and Swaine (1918). These are usually not cited in the text to avoid repetition, because each contains some information on many of the species treated herein. Only additional source references are listed under each species and, where the literature is extensive, an arbitrary selection was made to include those that presented new factual data or an extensive review; sometimes one of the references cited above is included because of its extensive review.

The nomenclature of the host plants follows Hosie (1969).

The photographs of the beetles or parts of beetles were taken in a JOEL JSM U-3 scanning electron microscope. The photographs of the antennae and tibiae were taken from gold-coated specimens, the remainder are of uncoated specimens.

Acknowledgments

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Key to the genera of Scolytidae in Canada and Alaska (Modified from Wood (1961))

1. Lateral margin of anterior and posterior tibiae unmodified except for a single curved process at outer apical angle (Fig. 56); antennal club (Fig. 60) flattened, the sutures strongly procurved; funicle 7-segmented (Fig. 60); elytra slightly or not declivous behind, the abdomen ascending abruptly behind to meet them (subfamily Scolytinae); Figs. 102 and 140 ..... ***Scolytus* Mueller**, p. 26

   Lateral margin of anterior tibiae with several toothlike processes, none of which curve toward the inner process (Figs. 55, 57–59); antennal club and funicle variable; elytra declivous behind, descending to meet the horizontal abdomen (subfamily Hylesininae) 2

2. Anterior margins of elytra raised and bearing a row of crenulations; scutellum, if visible, rounded, somewhat depressed and displaced posteriorly causing a slight emargination between bases of elytra; pronotum usually smooth; head usually visible from above 3

   Anterior margins of elytra unmodified, usually smooth and either rounded or with a fine raised line; scutellum flush with elytral surface, its anterior margin and elytral bases forming an almost transverse line across the body; pronotum roughened by asperities on anterior portion; head usually concealed from above 18

3. Lateral prosternal area sharply elevated from coxa to anterior margin; crenulations on elytral bases usually poorly developed; head somewhat prolonged, subrostrate; antennal funicle 7-segmented, club conical; eyes entire 4

   Prosternal area without elevated ridge; crenulations on elytral bases usually well-developed; head not prolonged, the frontal area usually sexually dimorphic; antennal funicle 4- to 7-segmented, club somewhat flattened; eyes variable 7

4. Crenulations on elytral bases rather well developed, forming a single row of teeth; segments 1 and 2 of antennal club subequal in length (Fig. 61); body less than 2.5 mm long, rather stout; in roots of herbaceous legumes; Figs. 103 and 141 ..... ***Hylastinus* Bedel**, p. 40

Crenulations on elytral bases rather poorly developed, irregularly placed, not forming a definite single row; segment 1 of antennal club distinctly longer than 2; body usually longer than 3 mm, very slender if smaller 5

5. Anterior coxae widely separated; general surface of elytra and between punctures on pronotum dull; vestiture sparse, recumbent, yellow; body reddish brown; Figs. 104 and 142 ..... ***Scierus*** **LeConte**, p. 41

Anterior coxae narrowly separated, almost contiguous; general surface of elytra and between punctures on pronotum smooth and shining; the longer vestiture erect; usually dark brown or black at maturity 6

6. Tarsal segment 3 broad, bilobed; pronotum usually constricted anteriorly, about equal numbers of large and small punctures intermixed on disk; Figs. 105 and 143 ..... ***Hylurgops*** **LeConte**, p. 43

Tarsal segment 3 narrower, emarginate; pronotum not noticeably constricted anteriorly, punctures uniformly large, intermixed with very few small punctures; Figs. 106 and 144 ..... ***Hylastes*** **Erichson**, p. 47

7. Scutellum visible, elytral bases notched for its reception; tarsal segment 3 stout, usually bilobed, sometimes slender 8

Scutellum not visible, elytral bases slightly or not at all emarginate at suture; tarsal segment 3 slender 16

8. Anterior coxae very narrowly separated, almost contiguous; antennal club nearly circular to transversely oval, strongly flattened, sutures sinuate (Fig. 63); submarginal epistomal process well-developed; Figs. 107 and 145 ..... ***Dendroctonus*** **Erichson**, p. 53

Anterior coxae widely separated; antennal club conical or flattened, sutures straight, oblique, transverse, or obsolete; epistomal process obsolete 9

9. Antennal club conical, weakly flattened, sutures transverse 10

Antennal club oval, strongly flattened, sutures subtransverse, oblique, or obsolete 14

10. Antennal funicle 5-segmented (Fig. 65); Figs. 109 and 147 ..... ***Xylechinus*** **Chapuis**, p. 65

Antennal funicle 7-segmented 11

11. Lateral areas of pronotum asperate; vestiture either entirely hairlike or entirely scalelike; in broadleaf trees 12

Lateral areas of pronotum smooth, punctate; vestiture of scales and hairs intermixed; in coniferous trees; Figs. 110 and 148 ..... ***Pseudohylesinus*** **Swaine**, p. 66

12. Eye entire, not emarginate; in *Ulmus* spp. or *Fraxinus* spp. 13

Eye shallowly emarginate; in *Alnus* spp.; Figs. 112 and 150 ..... ***Alniphagus*** **Swaine**, p. 74

13. Vestiture hairlike; pronotal asperities not prominent; in *Ulmus* spp.; Figs. 108 and 146 ..... ***Hylurgopinus*** **Swaine**, p. 76

Vestiture scalelike; pronotal asperities prominent; in *Fraxinus* spp.; Figs. 112 and 149 ..... ***Leperisinus*** **Reitter**, p. 77

14. Eye deeply emarginate; antennal club with three subtransverse or oblique sutures (Fig. 67); pronotum unarmed; in Cupressaceae trees, rarely other conifers; Figs. 113 and 151 ..... ***Phloeosinus*** **Chapuis**, p. 81

Eye entire; antennal club either deeply divided into three parts, or club solid and unmarked by sutures; pronotum usually armed by a few asperities in anterolateral areas 15

15. Antennal club deeply divided into three units (Fig. 69); vestiture hairlike; Figs. 114 and 152 ..... ***Phloeotribus*** **Latreille,** p. 92

Antennal club solid, unmarked by sutures (Fig. 70); vestiture scalelike; Figs. 115 and 153 ..... ***Chramesus*** **Chapuis,** p. 94

16. Scutellar area strongly raised and crenulate, crenulations restricted to area between elytral interspaces 5; eyes entire; antennal club narrower, distinctly longer than wide (Fig. 71); Figs. 117 and 154 ..... ***Chaetophloeus*** **LeConte,** p. 95

Scutellar area not raised, crenulations more generally distributed, extending laterally beyond elytral interspace 5; antennal club wider than long or nearly as long as wide 17

17. Antennal club marked by sutures (Fig. 72); eyes entire; Figs. 116 and 155 ..... ***Carphoborus*** **Eichhoff,** p. 96

Antennal club solid, unmarked by sutures (Fig. 73); eye divided into two parts; Figs. 118 and 156 ..... ***Polygraphus*** **Erichson,** p.102

18. Metepisternum visible to posterior extremity (Fig. 1); antennal club usually thickened basally, obliquely truncate or if flattened, the sutures, if visible, strongly displaced apically on posterior surface; antennal funicle 2- to 6-segmented 19

Metepisternum largely covered by elytra, visible only in front (Fig. 2); antennal club strongly flattened with sutures on both sides, those on posterior surface not strongly displaced apically; antennal funicle 1- to 5-segmented 39

19. Antennal funicle 6-segmented; anterior coxae moderately separated by an intercoxal piece; fore tibiae with sides parallel, usually with small teeth on apical margin (Fig. 58) 20

Antennal funicle 2- to 5-segmented; anterior coxae contiguous or very narrowly separated; fore tibiae broadened distally with teeth more widely distributed (Figs. 55, 59) 24

20. Elytra broadly rounded behind; margins of antennal club usually constricted at first suture (Fig. 75) 21

Elytra acuminate behind (Fig. 157); antennal club without sutural constrictions at sides (Fig. 74) 22

21. Pronotum wider than long, widest near base; pronotal summit more prominent; fore tibiae slender, mucro often bifurcate ..... ***Pseudothysanoes*** **Blackman,** p.103

Pronotum longer than wide, widest near middle; summit less prominent; fore tibia broad, mucro undivided ..... ***Thysanoes*** **LeConte,** p.104

22. Sutures of antennal club broadly procurved, the first extending less than one-third the length of club; scape club-shaped with a few setae; eye oval, rather small; fore tibia slender, slightly wider apically, with supplemental tubercles on posterior face ..... ***Hylocurus*** **Eichhoff,** p.105

Sutures of antennal club very strongly, narrowly procurved, the first usually reaching the middle of club; scape subtriangular, with numerous long setae, especially in females; eye elongate, rather large; fore tibia broad with parallel sides, posterior surface devoid of supplemental tubercles 23

23. Eyes moderately widely separated on gular area, the inner line entire; Figs. 119 and 157 ..... ***Micracis*** **LeConte,** p.106

Eyes narrowly separated on gular area, the inner line emarginate ... ***Micracisella*** **Blackman,** p. 108

24. Antennal club flattened, with sutures on both faces, those on posterior face strongly procurved and limited to apical half; costal margins of elytra at least slightly ascending posteriorly ... 25

Antennal club obliquely truncate or at least with sutures of posterior face restricted to less than apical one-quarter; costal margins of elytra descending posteriorly ... 28

25. Pronotum without a fine, raised lateral line; eyes sometimes sinuate, never emarginate; costal margins of elytra ascending only slightly posteriorly ... 26

Pronotum acutely margined at sides and with a fine raised line at least on basal one-third; eyes emarginate; costal margins of elytra distinctly ascending posteriorly ... 27

26. Antennal funicle 5-segmented, club narrow, pointed at tip, sutures straight, not septate (Fig. 76); basal half of pronotum without scalelike setae; Figs. 120 and 158 ... ***Trypophloeus*** **Fairmaire,** p. 108

Antennal funicle 4-segmented, club broadly rounded at tip, sutures straight, the first septate (Fig. 77); basal half of pronotum with scalelike setae; Figs. 121 and 159 ... ***Procryphalus*** **Hopkins,** p. 111

27. Antennal club not septate, with sutures indicated by rather strongly recurved rows of setae (Fig. 78); tarsal segment 3 broad and emarginate; body more than 1.4 mm long; Figs. 122 and 160 ... ***Cryphalus*** **Erichson,** p. 112

Antennal club with first suture partly septate; tarsal segment 3 cylindrical; body less than 1.3 mm long ... ***Hypothenemus*** **Westwood,** p. 114

28. Antennal funicle 2- or 3-segmented; pronotum smooth, punctured over entire surface, lateral line not raised; body usually shorter than 2 mm ... 29

Antennal funicle 4- or 5-segmented; pronotum usually with granules or asperities on anterior slope, if smooth, then lateral line sharply raised; body usually larger, mostly over 2 mm long ... 30

29. Antennal funicle 2-segmented, club with one obscure suture indicated at tip (Fig. 79); Figs. 123 and 161 ... ***Crypturgus*** **Erichson,** p. 114

Antennal funicle 3-segmented, club with three sutures indicated (Fig. 80); Figs. 124 and 162 ... ***Dolurgus*** **Eichhoff,** p. 116

30. Eye completely divided by an emargination; antennal funicle 4-segmented, club without distinct sutures ... 31

Eye never completely divided; antennal funicle 5-segmented (4-segmented in *Lymantor*), club usually with evident sutures ... 32

31. Antennal club with subcorneous basal area strongly, rather narrowly procurved (Fig. 81); anterior tibia of female thickened and tuberculate on posterior face, flattened and finely tuberculate in male; male head deeply excavated, the prothorax subquadrate; female frons convex, anterior margin of female pronotum rounded; Figs. 125 and 163 ... ***Trypodendron*** **Stephens,** p. 117

Antennal club with subcorneous basal portion broadly procurved (Fig. 82); anterior tibia flattened and devoid of tubercules on posterior face; frons not excavated in either sex; anterior margin of pronotum rounded in both sexes; Figs. 126 and 164 ... ***Xyloterinus*** **Swaine,** p. 122

32. Pronotum either punctate or finely granulate over almost entire surface, dorsal profile evenly convex, not strongly declivous anteriorly, anterior margin smooth; tibiae usually slender with a few coarse teeth; elytral declivity unmodified ... 33

Pronotum more coarsely asperate and more strongly declivous anteriorly, usually punctate at least on posterior third, anterior margin sometimes with erect asperities; tibiae variable; elytral declivity frequently with spinous processes 34

33. Antennal funicle 4-segmented, club compressed, sutures strongly arcuate; pronotum longer than wide; scutellum very small; Figs. 127 and 165 . . ***Lymantor*** **Lovendal**, p.123

Antennal funicle 5-segmented, club subtruncate, sutures transverse or recurved (Fig. 83); scutellum large; Figs. 128 and 166 ..... ***Dryocoetes*** **Eichhoff**, p.124

34. Meso- and meta-thoracic tibiae slender, abruptly narrowed apically, with a few widely spaced coarse teeth (Fig. 59); males and females similar in size and general shape 35

Meso- and meta-thoracic tibiae broadly dilated to a point slightly beyond the middle then gradually narrowed to apex, with a series of small closely set teeth, all about the same size and shape (Fig. 55); males rare, usually smaller and radically different in shape ..... ***Xyleborus*** **Eichhoff**, p.130

35. Elytral declivity narrowly bisulcate, margins moderately elevated, rounded, and with not more than three teeth; lower margin of declivity rounded; body usually smaller than 3 mm 36

Elytral declivity broadly, rather deeply excavated, margins acutely elevated, usually with more than three tubercules or teeth; lower margins of declivity provided with an acutely elevated transverse ridge separating declivital excavation from apical margin; body usually larger than 3 mm 38

36. Prosternal intercoxal piece short, obtuse; female frons deeply, rather narrowly excavated (Figs. 37 and 38); male declivity with two or three pairs of enlarged teeth; antennal club compressed, two sutures visible on distal third of posterior face (Fig. 85); Figs. 129 and 167 ..... ***Pityogenes*** **Bedel**, p.139

Prosternal intercoxal piece long and acutely tapered; female frons convex, not excavated; male declivity with two or three pairs of very small teeth; antennal club variable 37

37. Antennal club compressed, with two sutures visible on distal quarter of posterior face (Fig. 86); elytral declivity less strongly impressed, the lateral teeth minute; vestiture on anterior parts of pronotum and frons not especially long or abundant ..... ***Orthotomides*** **Wood**, p.144

Antennal club obliquely truncate, without sutures on posterior face (Fig. 87); elytral declivity more strongly impressed, the lateral teeth larger, especially in male (Figs. 39 and 40); vestiture much longer and more abundant on anterior part of pronotum and on frons in female; Figs. 130 and 168 ..... ***Pityokteines*** **Fuchs**, p.144

38. Antennal club obliquely truncate, the sutures recurved (Fig. 88); elytral declivity less strongly excavated, the third tooth displaced mesally, not on summit of declivital margin (Fig. 41); Figs. 131 and 169 ..... ***Orthotomicus*** **Ferrarie**, p.149

Antennal club not obliquely truncate, flattened, the sutures procurved, bisinuate or transverse (Figs. 89–94); elytral declivity broadly excavated, all teeth on summit of lateral margin (Figs. 42–51); Figs. 132 and 170 ..... ***Ips*** **De Geer**, p.150

39. Antennal funicle 5-segmented; outer face of fore tibiae smooth, not tuberculate; pubescence usually abundant 40

Antennal funicle 1- or 2-segmented; outer face of fore tibia usually distinctly tuberculate; pubescence much less abundant 44

40. Sutures of antennal club not septate; pronotal asperities usually extending behind middle at sides, the transition from asperate to punctured area gradual; body moderately to very stout 41

First and second sutures of antennal club septate; pronotal asperities usually not reaching middle, the transition from asperate to punctured area usually abrupt, summit usually well developed; body moderately stout to slender 42

41. Body usually smaller, 2.0–2.9 mm; anterior margin of pronotum rather coarsely serrate; pronotum with transverse impression behind summit; interspace 9 weakly elevated; antennal club distinctly longer than funicle; twig beetles, never found in cones ..... ***Myeloborus*** **Blackman,** p. 167

Body usually larger, 2.6–4.0 mm; anterior margin of pronotum feebly if at all serrate; pronotum without transverse impression behind summit; interspace 9 not elevated; antennal club and funicle equal in length (Fig. 95); in cones, rarely found in twigs of *Pinus* spp.; Figs. 134 and 172 ..... ***Conophthorus*** **Hopkins,** p. 169

42. Body slender to moderately stout; body surface smooth to rough, distinctly punctured and pubescent; antennal club and funicle of female devoid of special pubescence; twig and bark beetles 43

Body very slender; body surface smooth, punctures and pubescence nearly obsolete; antennal club and funicle of female with long, curved hairs (Fig. 97); ambrosia beetles; Figs. 135 and 173 ..... ***Gnathotrichus*** **Eichhoff,** p. 174

43. Pronotum and elytra minutely densely punctured; vestiture very short, usually dense; antennal club with segment 1 notably shorter than others (Fig. 98); greater development of frontal vestiture a male character; host *Quercus*, rarely other broadleaf trees; Figs. 136 and 174 ..... ***Pseudopityophthorus*** **Swaine,** p. 176

Pronotum and elytra more coarsely, less densely punctured; vestiture usually longer and less abundant; antennal club with segment 1 only slightly shorter or equal to others (Fig. 99); greater development of frontal vestiture a female character; Figs. 137 and 175 ..... ***Pityophthorus*** **Eichhoff,** p. 179

44. Antennal funicle 2-segmented (Fig. 100); posterior surface of fore tibia tuberculate; elytra emarginate or divaricate at sutural apex; Figs. 138 and 176 ..... ***Monarthrum*** **Kirsch,** p. 188

Antennal funicle 1-segmented (Fig. 101); posterior surface of fore tibia smooth; elytra evenly rounded behind, without a sutural notch at apex; Figs. 139 and 177 ..... ***Corthylus*** **Erichson,** p. 191

Subfamily Scolytinae

Genus *Scolytus* Geoffrey

Members of this genus are easily recognized by the abruptly ascending abdominal sternites (except *S. rugulosus* and *S. mali*) and by the broad, flattened, unarmed anterior tibia (Fig. 56). The most obvious characters are on the males, therefore sometimes the females are difficult to identify unless accompanied by males. Males are distinguishable by the strongly flattened frons; the frons of females is convex. The genus was revised by Blackman (1934), and the western species were reviewed by Edson (1967).

Key to the species of *Scolytus* in Canada and Alaska

1. Abdominal sternites unarmed in both sexes, sternite 2 not concave; elytral bases not strongly scabrous in either sex 2

   One or more abdominal sternites carinate, tuberculate, or armed with several teeth or spines in male at least (sometimes reduced in *subscaber*); sternite 2 either concave or convex; elytral bases usually scabrous in female 5

2. Ventral segments gradually ascending to elytra, sternite 2 oblique, not vertical (Figs. 5, 6); in deciduous trees 3

   Ventral segments abruptly ascending to elytra, sternite 2 vertical, concave or convex; in coniferous and deciduous trees 4

3. Smaller, less than 2.5 mm long; elytra with short hairs over entire surface; pronotal punctures large, deep, close; usually in fruit trees, Western and Eastern Canada (Fig. 5) ..... ***rugulosus*** **Ratzeburg**

   Larger, over 3.0 mm long; elytra glabrous on disk; pronotal punctures very fine, widely separated, shallow; various deciduous hosts, Eastern Canada (Fig. 6) ... . ***mali*** **(Beschtein)**

4. Elytral surface, frons, and ventral surface densely pubescent, especially in male; male frons strongly flattened, strongly sculptured; in *Celtis* spp., Eastern Canada (Fig. 7) ..... ***muticus*** **Say**

   Elytral surface, frons, and ventral surface not densely pubescent in either sex; male frons not as strongly flattened and not as strongly sculptured; in coniferous trees, Western Canada (Fig. 8) ..... ***tsugae*** **(Swaine)**

5. Sternite 2, in male at least, deeply concave, with anterior margin strongly extended, and usually carinate in median line; female with sternite 2 similar or convex with a more weakly elevated margin and carina reduced or lacking 6

   Sternite 2 in both sexes vertical, not concave, armed with a median tubercle, spine, or carina, anterior margin weakly produced 11

6. Sternite 2 of male very deeply concave, weakly carinate; posterior margin of sternite 4 with three long, acute spines, margin of sternite 5 with one acute spine (Fig. 9); male frons strongly flattened, densely pubescent on lateral margins; adults of both sexes from 3.0–5.0 mm long; in *Carya* spp., southeastern Canada .... ***quadrispinosus*** **Say**

   Sternite 2 of male not as deeply concave; posterior margin of sternites 4 and 5 unarmed; male frons not broadly flattened, pubescence more generally distributed; smaller in size; in Western Canada 7

7. Anterior margin of sternite 2 of male distinctly thickened; sternite 2 of male lacking an elevated, median carina or tubercle, surface faintly punctured, depressed in median portion; chiefly in *Pseudotsuga* spp. ..... ***oregoni*** **Blackman**

   Anterior margin of sternite 2 of male not especially thickened; sternite 2 of male bearing an elevated carina or tubercle, surface variously punctured; chiefly in *Abies* spp. 8

8. Sternite 2 of male bearing a strongly elevated median carina, which extends from the posterior margin to the center of the sternite, the carina more strongly elevated at its ventral apex 9

   Sternite 2 of male bearing a somewhat obscure median carina or small tubercle 10

9. Punctures of sternite 2 of male deeply impressed and close; front of male head flattened to a point just behind eyes; anterior margin of sternite 2 of female not strongly extended, surface of this sternite bearing a faint median carina at posterior margin ..... ***opacus abietis*** **Blackman**

Punctures of sternite 2 of male finely impressed, nearly obscure; front of male head flattened to a point well behind eyes; anterior margin of sternite 2 of female more strongly extended, surface of this sternite devoid of median carina ..... ***opacus opacus*** **Blackman**

10. Anterior margin of sternite 2 of male strongly produced and liplike at ventral apex (Fig. 10); posterior margin of sternite 2 of male extended medially to form an elevated carina or sharply pointed tubercle (Fig. 10); surface of sternite 2 dull ..... ***subscaber*** **LeConte**

Anterior margin of sternite 2 of male moderately and evenly elevated along entire surface (Fig. 11); posterior margin of sternite 2 of male bearing a small median tubercle (Fig. 11); surface of sternite 2 shining ..... ***ventralis*** **LeConte**

11. Carina or base of tubercle reaching posterior margin of sternite 2 of male (Fig. 12) ... 12

Carina or base of tubercle not reaching posterior margin of sternite 2 of male (Fig. 13) 14

12. Spine on sternite 2 of male stout, slightly compressed basally, distinctly rounded at apex; posterior margin of sternite 5 of male weakly elevated and strongly thickened; frons of male feebly concave, coarsely aciculate; in *Larix* spp. ..... ***laricis*** **Blackman**

Spine on sternite 2 of male long, more strongly compressed, and less rounded at the apex; sternite 5 of male with posterior margin moderately and evenly elevated; frons in both sexes finely to moderately concave; in *Pseudotsuga* spp. and *Abies* spp. 13

13. Base of spine reaching middle of sternite 2 of male (Fig. 12); sternite 2 subopaque; length of sternite 5 of male slightly less than sternite 3 and 4 combined ..... ***unispinosus*** **LeConte**

Base of spine reaching beyond middle of sternite 2 of male; sternite 2 shining; length of sternite 5 of male slightly more than length of sternite 4 ..... ***fiskei*** **Blackman**

14. Base of spine reaching anterior margin of sternite 2 (Fig. 13); punctures of elytral striae and interstriae subequal in size; in *Ulmus* spp. ..... ***multistriatus*** **Marsham**

Base of spine never reaching anterior margin of sternite 2; punctures of elytral striae distinctly larger than those of interstriae; in *Picea* spp. ..... ***piceae*** **(Swaine)**

Figs. 5–10. Venters of *Scolytus* spp. 5, *S. rugulosus;* 6, *S. mali;* 7, *S. muticus;* 8, *S. tsugae;* 9, *S. quadrispinosus;* 10, *S. subscaber.*

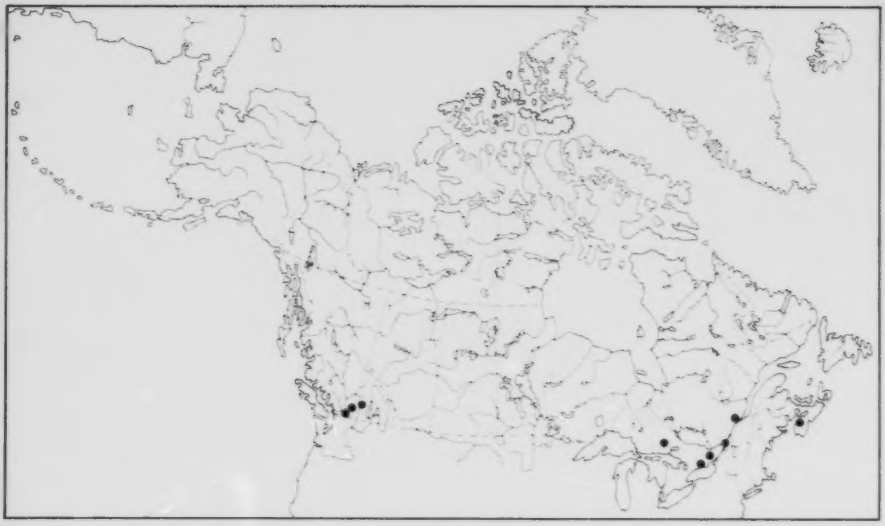
Figs. 11–13. Venters of *Scolytus* spp. 11, *S. ventralis;* 12, *S. unispinosus;* 13, *S. multistriatus.*

Scolytus rugulosus Ratzeburg (Fig. 5)

Diagnosis. Length 1.8–2.4 mm. Entirely black, or black with touches of red on margins, or entirely reddish brown: tarsi reddish; ♂ frons slightly flatter and more pubescent than ♀; ventral sternites gradually ascending to elytra.

Hosts. Various stone and pome fruit trees.

Distribution (Map 2). The fruit-growing regions of Eastern and Western Canada; United States and Europe.



Map 2. Distribution of *Scolytus rugulosus*.

Biology. Bright and Stark (1973) and Smith (1932, 1945).

The shot-hole borer, *S. rugulosus*, attacks and kills small twigs, limbs, and sometimes whole trees. Injury results from both adults and larvae feeding chiefly on twigs and limbs. Twig injury results from adults boring shallow feeding holes in the wood at the base of the buds. Limb injury, the typical scolytid damage, is caused by adult egg galleries and larval feeding, which may girdle the limb.

Adults can be found throughout the summer but the main attack period is from April through June. Females initiate the attack, boring small, round holes (1.3 mm) through the bark, generally in the center of lenticels, on injured, dying, dead, or (rarely) healthy trees. The attack may begin in an injured area (such as sunscald) on a healthy tree and spread throughout the tree.

The parent gallery lies in the cambium, slightly engraving the sapwood. The gallery usually extends straight up or down from the entrance tunnel for 1–5 cm. Eggs are deposited singly in closely spaced niches on both sides of the tunnel. The eggs hatch within a few days; larval galleries first extend at right angles to the parent gallery and then turn up or down with the grain of the wood. In heavy attacks, the larval galleries may intertwine and vary in length from 2.5 to 10 cm. At maturity the larvae generally burrow toward the center of the limb or trunk and penetrate about 16 mm into the wood. They then turn up or down and form rounded cells, in which they pupate. Some larvae of the summer generation pupate in the bark, but overwintering larvae are almost exclusively in the wood. The summer larval period lasts a little longer than a month.

The shot-hole borer overwinters in one of the various larval stages or as a pupa. The first emergence occurs about mid-March and emergence of the overwintering generation is usually complete by mid-May. The spring generation resulting from these adults is usually complete by the end of June. From this period until winter, distinct generations are impossible to distinguish. The number of generations per year in Canada is not known, but up to three complete generations per year are produced in California.

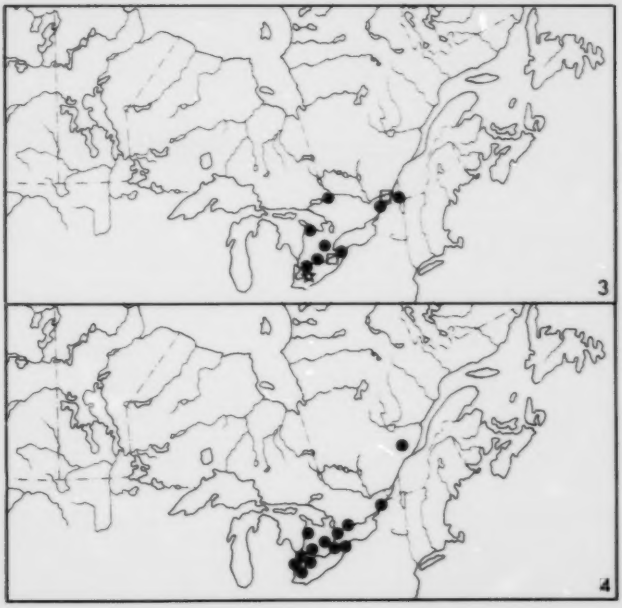
Scolytus mali (Beschtein) (***sulcatus*** LeConte) (Fig. 6)

Diagnosis. Length 3.3–4.2 mm. Head and prothorax black, elytra reddish or body entirely reddish brown; frons flattened, sparsely pubescent (♂) or strongly convex, sparsely pubescent (♀); sternite 5 weakly sulcate at apex (♂) or evenly rounded (♀); ventral sternites gradually ascending to elytra.

Hosts. Various species of broadleaf trees, recorded from various species of *Malus*, *Ulmus*, *Sorbus*, and *Pyrus*.

Distribution (Map 3). Southern Ontario and Quebec; eastern United States and Europe.

Biology. Not investigated.



Maps 3 and 4. Distribution of *Scolytus* spp. 3, *S. mali* (●), *S. quadrispinosus* (□), and *S. muticus* (◘); 4, *S. multistriatus*.

Scolytus muticus **Say (Fig. 7)**

Diagnosis. Length 2.8–4.4 mm. Black; densely pubescent; interstrial striae very long, especially in ♂; sternite 5 densely pubescent at apex (♂); frons flattened and pubescent, with fine sculpturing in ♀.

Hosts. *Celtis* spp.

Distribution (Map 3). Southern Ontario; eastern United States.

Biology. Harrick (1935).

This species, commonly known as the hackberry bark beetle, constructs short, vertical egg galleries under the bark of recently dead or dying hackberry. Larvae mine away from the egg gallery across the grain of the wood and, when mature, they usually burrow toward the center of the stem. Pupation takes place in a pupal cell deep in the wood.

Scolytus tsugae **(Swaine) (*monticolae* Swaine) (Figs. 8 and 56)**

Diagnosis. Length 2.8–3.5 mm. Black; frons flattened to weakly convex, coarsely aciculate (♂) or convex, more finely aciculate, punctate (♀); sternite 2 dull or shining; elytral interspaces rather deeply impressed.

Hosts. *Tsuga* spp., *Pseudotsuga menziesii*, and *Abies* spp.

Distribution (Map 5). Southern British Columbia, western Alberta; western United States.

Biology. Edson (1967) and McMillan and Atkins (1959).

The flight period of *S. tsugae* is from May to late July with a peak in mid-June. Attacks are initiated by the females, but males may assist in gallery construction. Although monogamous within galleries, the males may reemerge and mate with other females while they are constructing their galleries.

Attacks are made on dead or dying host material, usually when it is on the ground. Small, thin-barked branches and stems are preferred (6–18 cm in diam) but trees up to 33 cm in diam may be attacked. The entrance hole runs obliquely through the bark to the cambium, where a small turning niche or nuptial chamber is made. The gallery is usually constructed transversely to the grain in both directions from the entrance tunnel; it scores the sapwood to the same depth as the bark. Often, the egg tunnel runs longitudinally with or obliquely to the grain. The gallery is usually about 5 cm long.

Eggs are laid close together in niches cut on both sides of the gallery. Each female lays about 36 eggs. The larvae mine for a short distance at right angles to the parent gallery, then they turn toward the ends of the gallery. They overwinter as fourth-instar larvae and pupate in the cambium or in the bark in spring. Thus, one generation is produced per year.

Scolytus quadrispinosus **Say (*caryae* Riley) (Fig. 9)**

Diagnosis. Length 3.0–5.0 mm. Black to reddish brown; frons subconvex, finely aciculate, sparsely pubescent (♀) or flattened, strongly aciculate, densely pubescent on lateral margins (♂); sternites unarmed (♀) or as in Fig. 9 (♂); elytral striae strongly impressed; interspaces much more finely punctured and much less impressed; elytral surface shining.

Hosts. *Carya* spp.

Distribution (Map 3). Southern Ontario and Quebec; eastern United States

Biology. Baker (1972).

This species is commonly known as the hickory bark beetle. It is widely distributed and can be very destructive in the eastern United States.

Adults appear in early summer; they feed for a short time at the bases of leaf petioles and on the twigs of hickory before flying to the trunks and branches of living trees. Short, longitudinal egg galleries are constructed under the bark. In thick-barked trees, the gallery may scarcely touch the wood; in thin-barked limbs, it may be entirely in the wood. The larvae feed in the phloem, gradually angling away from the egg gallery. Before reaching maturity, they enter the bark, where they construct pupal cells. The winter is spent in the larval stage, and pupation occurs in the spring. One generation is completed per year.

Except during drought, damage is usually confined to individual trees. The foliage of heavily infested trees turns red within a few weeks of attack, and the tree soon dies.

Scolytus oregoni **Blackman**

Diagnosis. Length 2.7–3.5 mm. Black to reddish brown; frons flattened to well behind eyes, moderately finely aciculate (♂) or convex, finely aciculate-punctate; anterior margin of sternite 2 distinctly thickened in both sexes; posterior margin of sternite usually bearing a faint median tubercle (♂) or without any trace of a median tubercle (♀).

Hosts. *Pseudotsuga menziesii.*

Distribution. Not recorded from Canada, but probably occurs in coastal British Columbia; known from Washington to California.

Biology. Edson (1967).

The gallery of this species is usually constructed with the grain of the wood, with a central nuptial chamber. The adult gallery is deeper in the sapwood than in the phloem and is 6–18 cm long. Egg niches score the sapwood rather deeply and are usually in pairs along the gallery. The larval mines form a fan-shaped pattern when uncrowded, terminating in pupal chambers. This species prefers the larger limbs of its host plant.

Scolytus opacus abietis Blackman

Diagnosis. Length 2.1–2.8 mm. Black to dark reddish brown; frons flattened to just back of eyes, finely aciculate-punctate (♂) or convex, more finely aciculate-punctate (♀); anterior margin of sternite 2 strongly (♂) or weakly (♀) extended; carina on sternite 2 thick, very strongly elevated, highest at or near center of sternite (♂) or very feebly developed, extending scarcely to center of sternite (♀); surface of sternite 2 shiny, deeply, closely punctured (♂).

Hosts. *Abies* spp.

Distribution. Not recorded from Canada, but probably occurs in southern British Columbia; known from Washington to California, east to Idaho.

Biology. Edson (1967).

This species attacks smaller limbs and tops of living trees but prefers fresh slash. The adult gallery usually has one arm extending across the grain from the central nuptial chamber and the other at a 45° angle to the grain. However, both galleries may be at right angles or oblique to the grain. The galleries are usually 2–5 cm long.

Egg niches are closely placed; they lightly score the sapwood. Larval mines extend nearly parallel to one another, if not crowded, and terminate in elliptical pupal chambers.

Scolytus opacus opacus Blackman

Diagnosis. Length 2.5–3.4 mm. Shining black; frons flattened to a point well behind the eyes, moderately finely aciculate-punctate (♂) or convex, more finely aciculate (♀); anterior margin of sternite 2 strongly (♂) to weakly (♀) extended; carina on sternite 2 as in *abietis* described above; surface of sternite 2 opaque, indistinctly punctured.

Hosts. *Abies* spp.

Distribution. Not recorded from Canada, but probably occurs in the Rocky Mountain regions of British Columbia and Alberta; known from Idaho and Montana to Colorado and Utah.

Biology. Edson (1967).

The biology of this species is very similar to that of the other subspecies, *S. opacus abietis*.

Scolytus subscaber LeConte (Fig. 10)

Diagnosis. Length 3.2–4.9 mm. Black to reddish brown; frons strongly flattened, coarsely aciculate (♂) or convex, finely aciculate (♀); anterior margin of sternite 2 distinctly produced and liplike (♂) or very weakly produced, rounded (♀); posterior margin of sternite 2 with a slightly elevated carina (♂).

Hosts. *Abies* spp.

Distribution (Map 6). Southern British Columbia; Pacific Coast states east into Idaho.

Biology. Edson (1967) and Struble (1957).

Adults of this species attack branches or trunks of small (under 10 cm) suppressed trees in July and August. The parent gallery resembles a rounded capital E. The nuptial chamber or entrance hole is central with two short egg galleries (total length about 2 cm) recurving around it. The parent gallery is etched deep into the sapwood. A fungus stain organism is introduced by the attacking beetle.

About 12–30 eggs are deposited in the cambium on the outer margin of the gallery. The larvae do not score the sapwood until they are nearly full-grown. They mine the sapwood slightly when the pupal chamber is being excavated. Larval mines are about 14 mm long.

One generation is produced per year; the beetles overwinter as larvae.

Scolytus ventralis LeConte (Figs. 11, 60, and 178)

Diagnosis. Length 3.3–4.3 mm. Black to reddish brown; frons as in *subscaber;* anterior margin of sternite 2 (♂) moderately and evenly produced or weakly produced, rounded (♀); posterior margin of sternite 2 (♂) produced into an acute tubercle.

Hosts. *Abies* spp., *Pseudotsuga menziesii, Picea* spp., and *Tsuga* spp.

Distribution (Map 6). Southern British Columbia; western United States.

Biology. Ashraf and Berryman (1969), Berryman (1968*a*, *b*), Stark and Borden (1965), Stevens (1971), and Struble (1957).

Attacks are made from June through September, but peak activity is during July and August. Individual branches are commonly infested causing "flagging," but trees from pole size to the largest sawtimber size are attacked throughout their length. Location of attack on the stem is extremely variable. The female enters first, followed soon after by the male, who helps to remove boring dust from the gallery. A fungus stain, *Trichasporium symbioticum* Wright, is introduced by the beetle and spreads rapidly in all directions from the egg gallery.

Egg galleries are constructed horizontally, extending 5–8 cm in both directions from the nuptial chamber (Fig. 178). Egg niches, spaced 1–1.5 mm apart, are excavated on both sides of the gallery. The number of eggs laid varies considerably, but the average in small trees (under 18 cm DBH) is about 57 per gallery. A maximum of 260 has been found.

Larvae mine at right angles to the parent gallery and parallel to one another. The larval mines may be longer than the parent gallery. Development

time of larvae varies from 41 days at low elevations in the south to 380 days at high elevations and in northern latitudes. The pupal cells are elongate and may be entirely in the bark. The beetles overwinter as larvae and adults.

The number of generations per year varies. At lower elevations (1050–1250 m) and on southern exposures, there may be one complete and a partial second generation per year. At 1250–1800 m, there is usually one per year, whereas at altitudes above 1800 m, the complete life cycle may require 2 years.

Scolytus laricis Blackman

Diagnosis. Length 2.6–3.5 mm. Black; frons slightly concave, coarsely aciculate (♂) or convex, finely sculptured (♀); posterior margin of sternite 5 weakly elevated, strongly thickened (♂); spine on sternite 2 stout, apex distinctly rounded (♂).

Host. *Larix occidentalis.*

Distribution. Southern British Columbia; Pacific Northwest states.

Biology. Edson (1967).

Little is known of the biology of this species except the gallery pattern. The egg gallery consists of two arms, one extending up and the other extending downward from the nuptial chamber. Both galleries are constructed with the grain of the wood. The length is 4–11.5 cm. The galleries deeply engrave the wood. Larval mines extend away from the egg galleries and are straight or gradually divergent. Pupal chambers, constructed at the ends of the larval mines, score the sapwood rather deeply.

This species is very similar to *S. unispinosus* and is probably only a biological race.

Scolytus unispinosus LeConte (*sobrinus* Blackman) (Fig. 12)

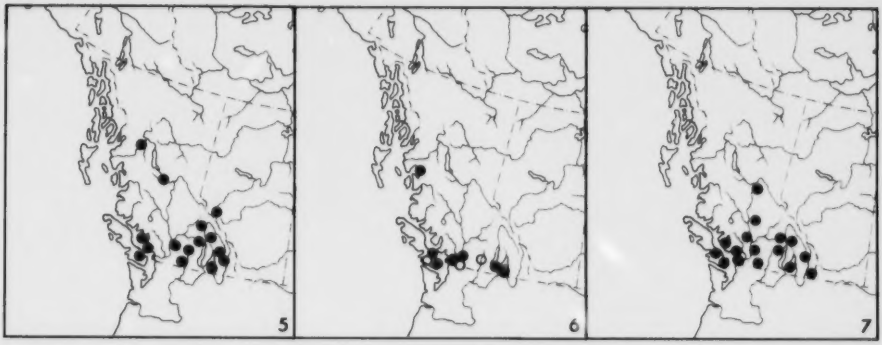
Diagnosis. Length 2.3–3.1 mm. Black; frons slightly convex, finely aciculate (♂) or moderately convex, finely sculptured (♀); spine on sternite 2 (♂) strongly compressed, less rounded at apex than in preceding species; posterior margin of sternite 5 moderately and evenly rounded.

Hosts. *Pseudotsuga menziesii, Abies* spp., and *Tsuga* spp.

Distribution (Map 7). Southern British Columbia; western United States.

Biology. Daterman et al. (1965), Edson (1967), and McMullen and Atkins (1962).

The flight period of *S. unispinosus* commonly occurs from late June to the end of August, but flight has been observed as early as mid-May. Attacks are



Maps 5–7. Distribution of *Scolytus* spp. 5, *S. tsugae*; 6, *S. subscaber* (○) and *S. ventralis* (●); 7, *S. unispinosus*.

often intermixed with *S. tsugae* in the tops and limbs of trees killed by the Douglas fir beetle, *Dendroctonus pseudotsugae*. *S. unispinosus* is most successful in smaller branches and limbs. It has been observed attacking and killing twigs in Douglas-fir reproduction.

The parent galleries are constructed by the females. Apparently most of the galleries are forked, extending in both directions from the nuptial chamber, but a significant number extend in only one direction from the nuptial chamber. Both types of gallery are constructed parallel to the grain of wood. A gallery is usually about 3.5 cm long; the longest is 7 cm.

Eggs are laid singly on both sides of the gallery about 1 cm apart. The maximum number per gallery is 60. Larvae appear from June to mid-July, and their mines fan out at right angles to the egg gallery. A gallery is usually about 3 cm long; the longest is 5 cm. Pupation occurs at the cambium–wood interface or just beneath the outer bark scales.

There is only one generation per year in Canada.

Scolytus fiskei Blackman

Diagnosis. Length 2.4–3.4 mm. Black; closely resembles *unispinosus* and may be only a subspecies or possibly a synonym. Differs by having a spine on sternite 2 (♂) extending from the posterior margin of the sternite about three-quarters the length of the sternite; and sternite 2 is black, shining, and finely and distinctly punctured.

Hosts. *Pseudotsuga menziesii* and *Abies* spp.

Distribution. Southern British Columbia; western United States.

Biology. Edson (1967).

The life cycle and gallery pattern of this species is nearly identical with that of *S. unispinosus*.

Scolytus multistriatus Marsham (Fig. 13)

Diagnosis. Length 2.2–3.0 mm. Dark reddish brown; frons strongly flattened to behind the eyes, aciculate-punctate, pubescence abundant (♂), or convex, finely aciculate-punctate (♀); elytral striae impressed slightly; spine on sternite 2 of both sexes arising on anterior third.

Hosts. *Ulmus* spp.

Distribution (Map 4). Eastern Canada east of Lake Superior; United States except in the far west and Europe.

Biology. Becker and Mankowsky (1965), Brown (1965), Brown and Eads (1966), and Whitten and Reeks (1967).

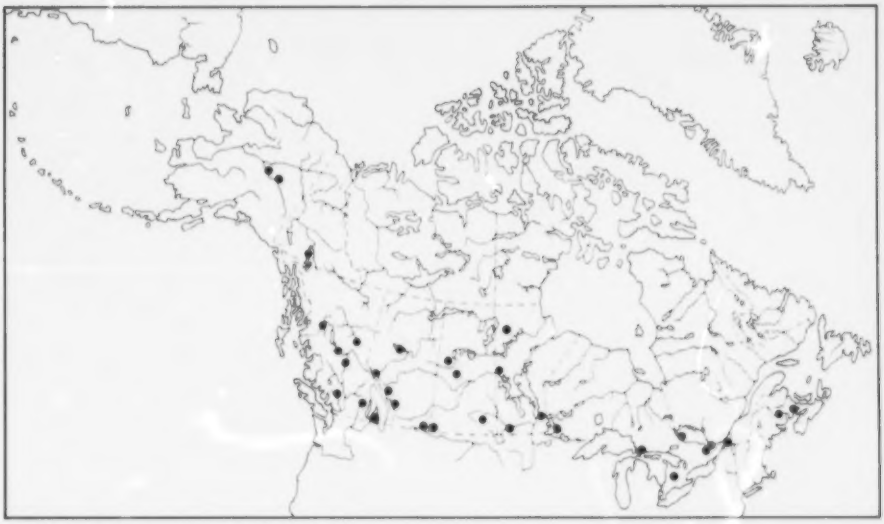
This European species, commonly known as the smaller European elm bark beetle, was accidentally introduced into the United States and was first recorded from Cambridge, Massachusetts, in 1909. Since then, the species has spread throughout most of the United States; it entered Canada near Windsor, Ontario, in 1948.

Attacks by *S. multistriatus* beetles cause little damage by feeding and mining, but they are one of the principal vectors of the fungus *Ceratocystis ulmi* (Buism.) Moreau, which causes the Dutch elm disease. This vascular wilt disease produces wilting and yellowing or dying of foliage, followed immediately by defoliation and death of affected branches. Infected trees may die gradually over several years but often death occurs within a few weeks. There is no known cure for the disease. The disease occurs in Washington and Oregon, to within 50 miles of the Manitoba border in North Dakota, in South Dakota, in Minnesota almost to Fort Frances, Ontario, and from Lake Superior to Cape Breton Island, Nova Scotia. Suspected cases from Winnipeg have not been confirmed. The disease is widespread in the United States east of the Rocky Mountains. Apparently, low temperatures in winter have slowed the northward advance of the disease. Along the north shore of Lake Ontario, and in North Dakota, Minnesota, and probably the New England States, the northern limit of distribution has changed little since 1959.

Adults of this species feed on living elm throughout the entire growing season of the tree. Before the beetles bore into the tree to breed, they feed in the crotches of the smaller twigs. After mating takes place on the trunk of the tree, the female bores into the cambium layer and excavates the egg gallery.

The egg gallery is constructed to run with the grain of the wood, engraving both bark and wood for 2.5–5 cm. From 24 to 96 eggs are deposited in niches on both sides of the gallery. The larvae mine at right angles to the parent gallery, but they gradually turn and continue obliquely or parallel to the grain so that the final gallery pattern is nearly circular in outline. Larval galleries are usually longer than egg galleries, often reaching lengths of 20 cm. Before the larvae pupate, they bore into the bark and excavate a pupal chamber.

This species overwinters in the larval stage; the adult beetles emerge in June or July and feed in the bark of small branches and twigs. Most of the progeny of these adults emerge in August and September. However, some of them do not complete their development during the first summer; these remain as larvae,



Map 8. Distribution of *Scolytus piceae*.

which form a large part of the overwintering population. Only a few of the adults that emerge in late summer are able to breed, oviposit, and give rise to overwintering larvae. The rest feed and die with the approach of cold weather without establishing a brood. One generation and part of a second is produced each year in Canada.

Scolytus piceae (Swaine) (Figs. 102 and 140)

Diagnosis. Length 2.4–3.3 mm. Shining black; frons flattened to behind the eyes, impressed between eyes (♂) or convex, finely aciculate-punctate (♀); elytral striae variably impressed; spine on sternite 2 of both sexes arising from center of sternite.

Hosts. *Picea* spp.; rarely *Abies* spp. and *Larix* spp.

Distribution (Map 8). Transcontinental in Canada; eastern and western United States.

Biology. Edson (1967).

S. piceae usually attacks dead and dying limbs. The parent galleries may have two or three branches radiating from the central nuptial chamber. If there are two branches, one usually extends directly with the grain, the other extends at right angles for a short distance before turning with the grain. If three female

tunnels are present, the gallery outline will resemble a tuning fork. The gallery is 5–8 cm long, and usually deeply scores the sapwood.

From 10 to 30 eggs are laid in deep niches on both sides of the tunnels. Larval mines start off at right angles but soon turn and follow the grain, scoring the wood deeply. The gallery is ultimately fan-shaped. Pupal chambers are circular, and these and the larval mines also etch the sapwood deeply.

There is probably one generation per year.

Subfamily Hylesininae
Genus *Hylastinus* Bedel

Hylastinus obscurus (Marsham) (Figs. 1, 61, 103, and 141)

Diagnosis. Length 2.3–2.6 mm. Frons convex, impressed above epistoma; pronotal punctures close and deep, evenly placed; elytral strial punctures large, deep; elytral interspaces tuberculate or rugose, the tubercles more acute and prominent on declivity.

Hosts. Wild and cultivated legumes, clover, beans, and vetch.

Distribution (Map 9). Southern British Columbia, southern Ontario, Quebec, Nova Scotia; eastern and western United States.

Map 9. Distribution of *Hylastinus obscurus*.

Biology. Rockwood (1926).

Fresh attacks are made in the spring on the roots or root crowns, slightly below the soil surface. Parent galleries, usually 2–4 cm long, run with the root fiber, but are occasionally horizontal. Typically a single female and male are found in each burrow, but occasionally two females may be present. Many females excavate up to four separate egg galleries.

Eggs are deposited in niches on the sides of the galleries. Only 4–9 eggs are laid per gallery on legumes, but in larger plants the number may reach 30–40. Each female lays about 40 eggs. The larvae feed in roots all summer and may even overwinter there, pupating and emerging in the spring. Most of them, however, overwinter as adults.

One generation is produced per year.

This species, commonly known as the clover root borer, is a serious pest of clover and alfalfa in the eastern United States. It is considered to be one of the main factors limiting the life of red clover.

Genus *Sclerus* LeConte

Members of this genus are distinguished by their dull reddish brown color and stout body. The elytral striae are impressed and punctured in regular rows, the interspaces are rugose, and the declivity is more strongly rugose.

Key to the species of *Sclerus* in Canada

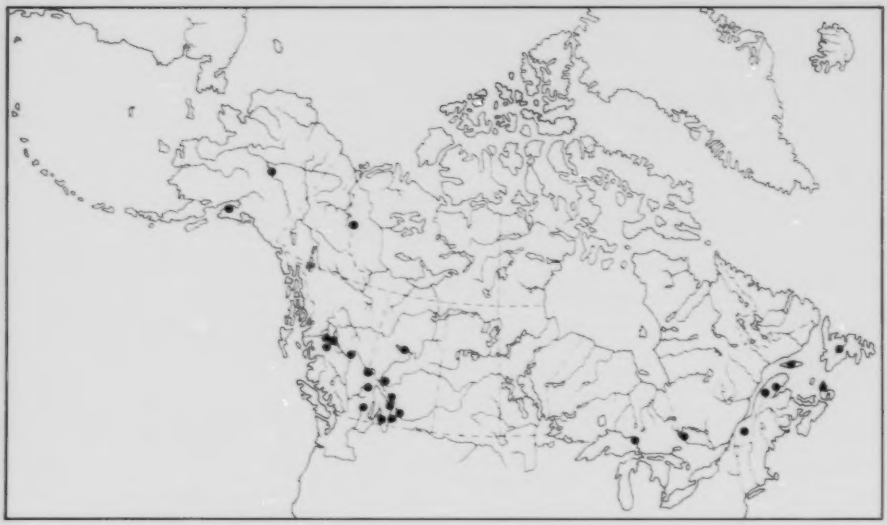
1. Interstrial setae much shorter than interstrial width; surface of pronotum very dull, opaque; body 3.0–3.7 mm long ..... ***annectans*** **LeConte**

   Interstrial setae as long as or longer than interstrial width; surface of pronotum moderately shining; body 3.9–4.5 mm long ..... ***pubescens*** **Swaine**

Sclerus annectans LeConte (Figs. 104 and 142)

Diagnosis. Length 3.0–3.7 mm. Light to dark reddish brown; frons convex, transversely impressed at about the middle, punctures large, deep; striae punctured in regular rows, punctures deeply impressed; interspaces densely rugose; declivital interspace 2 slightly impressed; all interspaces tuberculate, especially on declivity.

Hosts. *Picea* spp., *Abies lasiocarpa*, and *Pinus contorta*.



Map 10. Distribution of *Scierus annectans*.

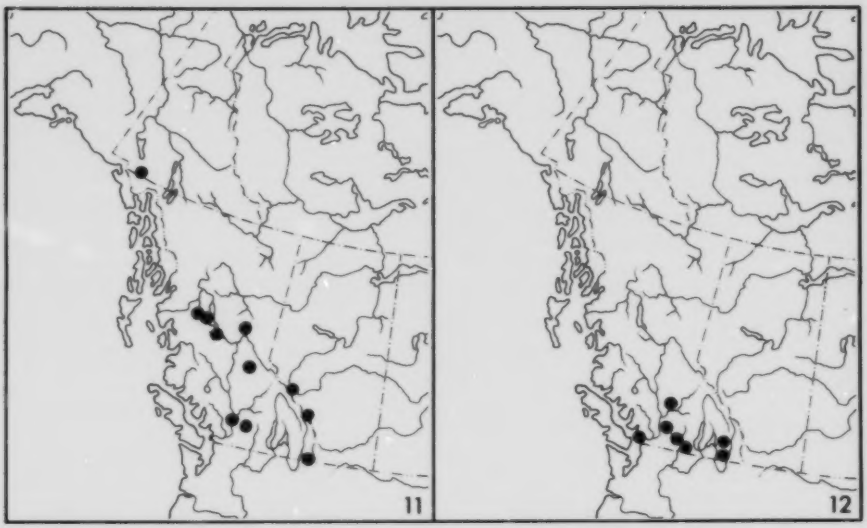
Distribution (Map 10). Transcontinental in Canada; northeastern and western United States.

Biology. Stewart (1965).

Spring flight and attack on hosts take place from mid-June to mid-August; the main attack is in mid-July. Entrance to the cambium of the host is usually made through entrance holes bored by *Dendroctonus rufipennis* (Kirby), the spruce beetle. Preference is shown for the holes on the underside of felled or leaning trees. Up to five *Scierus* attacks are made in each *Dendroctonus* hole. After the beetle reaches the cambium, it constructs a characteristic "turning niche," slightly longer than the beetle. This side niche makes it easier for the beetle to exit in a forward position. The egg gallery is longitudinal, slightly curved, and parallel with or at a 45° angle to the grain of the wood. The sapwood is only slightly etched, if at all.

Oviposition begins during gallery construction. The female extends the gallery just beyond the proposed niche, excavates the short, lateral egg niche in the outer cambium, deposits the egg, packs it in with frass, and then repeats this activity. After oviposition, the gallery is extended farther, presumably by the adult feeding. The gallery is usually about 33 mm long, a maximum of 42 mm has been recorded.

Oviposition takes place throughout July and early August. Larvae are found about 3 weeks later. Usually 10–16 eggs are laid, but up to 32 have been found. Larvae burrow at right angles to the parent gallery, but their galleries may meander and often cross one another.



Maps 11 and 12. 11, Distribution of *Scierus pubescens*. 12, Distribution of *Hylurgops subcostulatus*.

Scierus pubescens Swaine

Diagnosis. Length 3.9–4.5 mm. Reddish brown; pronotum more shining than *S. annectans;* interstrial setae much longer than in *S. annectans.*

Hosts. *Picea* spp., *Abies lasiocarpa*, and *Pinus contorta.*

Distribution (Map 11). Western Canada; Pacific Northwest states.

Biology. Not investigated but probably similar to *S. annectans.*

Genus *Hylurgops* LeConte

Members of this genus are distinguishable by the broad and bilobed third tarsal segment and by the anteriorly constricted pronotum, which, on the surface, bears an equal number of large and small punctures intermixed.

Specimens are found, often in large numbers, in old, dead logs and stumps. The larvae work gregariously. It is usually difficult to follow any design in the construction of their galleries.

Key to the species of *Hylurgops* in Canada and Alaska

1. Elytral interspaces 1, 3, and 5 strongly elevated on declivity; pronotum and elytra reddish, densely scaly, often encrusted; declivital interspaces 2, 4, etc., without erect, hairlike setae ..... ***subcostulatus* (Mannerheim)**

All elytral interspaces of equal or very nearly equal height on declivity; pronotum and elytra black or red, but not densely scaly and seldom encrusted; all declivital interspaces having erect or semierect, hairlike setae 2

2. Sides of pronotum strongly arcuate, strongly constricted on anterior third; body stout, less than 2.5 times longer than wide; dorsal surface usually reddish, ventral surface darker 3

Sides of pronotum evenly arcuate or weakly constructed on anterior third; body more elongate, 2.6–2.7 times longer than wide; dorsal and ventral surfaces usually similar, sometimes elytra slightly lighter 4

3. Eastern Canada, west to Alberta; in *Pinus banksiana, P. strobus, Picea* spp., and occasionally *Larix* spp. ..... ***pinifex*** **(Fitch)**

Western Canada and Alaska; in *Pinus contorta*, various coastal pines, *Picea* spp., rarely other species of conifers ..... ***rugipennis*** **(Mannerheim)**

4. Elytra brightly shining, smooth between punctures and granules; surface between pronotal punctures smooth, shining ..... ***porosus*** **LeConte**

Elytra dull, minutely reticulate between punctures and granules; surface between pronotal punctures dull, reticulate ..... ***reticulatus*** **Wood**

Hylurgops subcostulatus (Mannerheim)

Diagnosis. Length 3.4–4.5 mm. Reddish to rusty brown, black beneath; frons transversely impressed above epistoma, densely punctate; pronotal surface with large, deep punctures and numerous smaller, shallower punctures between; alternate elytral interspaces elevated on declivity, the elevated interspaces distinctly granulate on summit; vestiture of small, stout, scalelike setae on the elevated interspaces.

Hosts. *Pinus ponderosa* in Canada, but other species of pines elsewhere.

Distribution (Map 12). Southern British Columbia; western United States.

Biology. Bright and Stark (1973).

Attack is made on the basal portion of the trunk of recently killed pines, especially those with wet fermenting sap. The parent gallery is short, slightly irregular, and usually runs in a longitudinal direction. The larvae work in all directions with no clearly differentiated mines. The entire cambial layer may be eaten during heavy attacks. Pupation takes place in the cambium region or inner bark.

Trees are attacked in early spring and summer; resulting broods emerge in the fall and reattack the same log or a new one. This second generation overwinters under the bark as larvae and new adults. There is probably only one generation per year.

Hylurgops pinifex (Fitch)

Diagnosis. Length 4.0–5.0 mm. Reddish brown to black, black beneath; sides of pronotum constricted in front of middle; elytra slightly widened

behind middle; elytral interspaces convex, granulate, more granulate on declivity; vestiture on elytra consisting of recumbent, narrowly to broadly flattened, scalelike setae on interspaces with a median row of erect, hairlike setae. Intergrades with *rugipennis* in Alberta.

Hosts. *Pinus* spp. and *Picea* spp.; occasionally *Larix laricina*.

Distribution (Map 13). Eastern Canada west to Alberta; eastern United States.

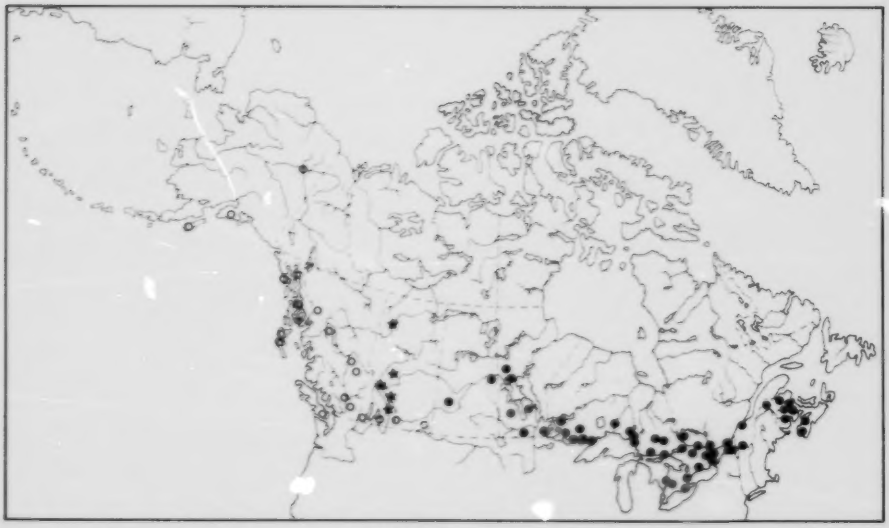
Biology. Blackman (1919).

This is a common species in Eastern Canada as far west as Alberta. It is a secondary species, which prefers the thick bark portion of the trees, mainly found in stumps, logs, or the lower part of standing trees. Quite often adults are found some distance below ground level in the roots.

Adults are monogamous and the egg tunnels are longitudinal, straight to slightly sinuous. The egg gallery usually extends down from the nuptial chamber but many galleries extend up from the entrance. A turning niche or nuptial chamber is located at the beginning of the egg tunnel. Completed galleries are 2.5–9 cm long.

From two to six eggs are deposited in grooves or pockets constructed on both sides of the tunnel. In the grooves, the eggs are placed in several tiers, each tier carefully partitioned off with frass and boring dust. When the larvae hatch, they feed communally, excavating large areas of cambium. Pupation takes place in a pupal cell constructed in the bark, cambium, or wood.

There is probably one generation per year in Canada.



Map 13. Distribution of *Hylurgops pinifex* (●), *H. rugipennis* (○), and intermediate forms (★).

Hylurgops rugipennis **(Mannerheim) (Figs. 57, 105, and 143)**

Diagnosis. Length 4.0–5.0 mm. Reddish to light reddish brown, black beneath. Identical in essential respects with *H. pinifex*. Evidently hybridizes with *H. pinifex* in Alberta and southwestern British Columbia.

Hosts. *Pinus* spp., *Picea* spp., *Pseudotsuga menziesii*, and *Abies* spp.

Distribution (Map 13). Alaska, Alberta, British Columbia; western United States.

Biology. Reid (1955).

Adults of this species attack the stumps, just above the duff layer. Galleries extend several centimetres above and below the entrance hole. Eggs are laid in depressions along the sides of the galleries, from one to five in depth, and they are packed in with boring dust.

The entire brood works down from the egg gallery in a large group, but later they separate into smaller groups, and by the time the larvae have reached maturity they are alone or in groups of two to six. Larvae also work down into the taproot, located in the mineral soil, and also are found in the large lateral roots.

Measurements of the head capsule indicate four larval instars.

In Alberta, the life cycle varies from 1½ to 2½ years, resulting in a flight period throughout most of the summer. Larvae and adults are the overwintering stages. Adults attack in early spring, and by September most of the progeny are in the larval stage; a few have pupated and become adults. The larvae in this generation either remain as larvae throughout the following summer, or pupate in late summer and reach the young-adult stage before winter. These young adults emerge, but do not establish broods until the following year. Those larvae that do not pupate the second summer overwinter and pupate in the early spring.

Hylurgops porosus **LeConte (*lecontei* Swaine)**

Diagnosis. Length 3.5–4.5 mm. Reddish brown to black; frons subrostrate, densely punctured, impressed at about middle and above epistoma, divided by a rather sharp, low, longitudinal carina; pronotum shining, densely punctured, weakly rugose; strial punctures large and deep; elytral interspaces strongly crenulate with numerous small punctures, granulate near declivity; first and third declivital interspaces bearing a median row of fine granules; vestiture scalelike on declivity.

Hosts. *Pinus* spp.

Distribution (Map 14). Western Canada; western United States.

Biology. Not investigated.

Hylurgops reticulatus Wood

Diagnosis. Length 3.7–5.0 mm. Black; frons as in *porosus* except less finely punctured; pronotal surface reticulate between punctures; elytra as in *porosus* except surface of interspaces reticulate and granules slightly larger.

Hosts. *Pinus ponderosa, P. contorta, Pseudotsuga menziesii,* and *Tsuga heterophylla.*

Distribution (Map 15). Southern British Columbia; western United States.

Biology. Not investigated.

Genus *Hylastes* Erichson

Members of this genus are difficult to distinguish from those in *Hylurgops.* The characters given in the key and the illustrations should be sufficient to distinguish between the two genera. Blackman (1941) produced a key to the species.

Adults occasionally kill pine transplants or young plantation trees by chewing the bases of the stems; otherwise the species are of minor economic importance.

Key to the species of *Hylastes* in Canada

1. Occurs in Eastern Canada; body 3.9–5.3 mm long; median carina on frons sharply elevated, often extending above the strong transverse impression .... ***porculus*** **Erichson**

   Occurs in Western Canada; body length variable; frons with or without a median carina, if carina present, it is weakly elevated 2

2. Body less than 3 mm long; epistoma not divided by a raised carina; elytral interspaces clothed with hairlike setae about as long as the interstrial width, and a few stout scalelike setae on the declivital interspaces ..... ***tenuis*** **Eichhoff**

   Body more than 3 mm long; epistoma divided by a distinct raised carina; elytral vestiture variable 3

3. Body more than 5.0 mm long; pronotum distinctly and roughly punctured ..... ***macer*** **LeConte**

   Body less than 5.0 mm long; pronotum finely punctured 4

4. Mature body bright red to reddish brown; body moderately stout; 2.8 times longer than wide ..... ***ruber*** **Swaine**

   Mature body brown to black; body more slender 5

5. Body 2.8–3.0 times longer than wide; pronotum widest at or near middle ..... ***nigrinus*** **(Mannerheim)**

   Body more than three times longer than wide; pronotum widest in front of middle 6

6. Pronotum 1.2 times longer than wide, only slightly narrower than elytra; elytral interspaces equal to or wider than striae; pubescence scanty on disk ..... ***gracilis*** **LeConte**

Pronotum 1.3 times longer than wide, distinctly narrower than elytra; elytral interspaces narrower than striae; pubescence longer and more abundant ..... ***longicollis*** **Swaine**

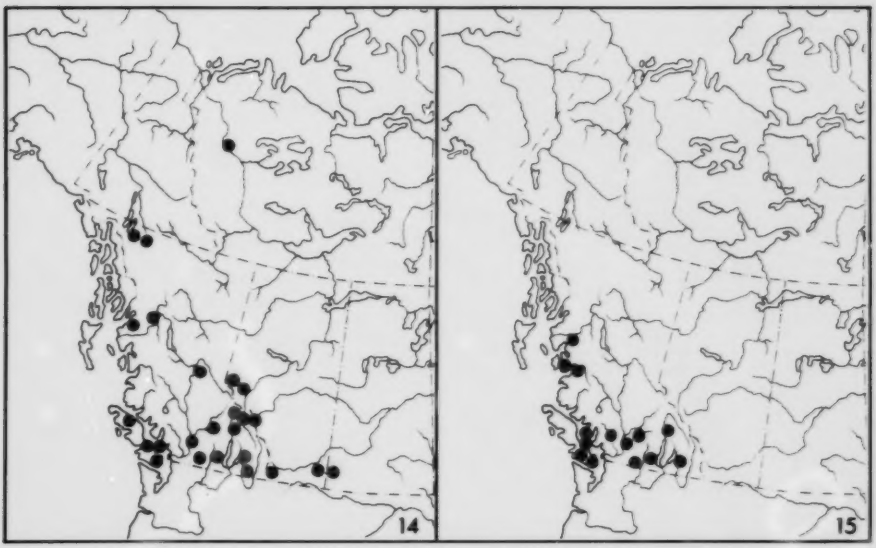
Hylastes porculus Erichson (***carbonarius*** Fitch, ***granosus*** Chapuis, ***cavernosus*** Zimmermann, ***scaber*** Swaine, ***swainei*** Eggers, ***canadensis*** Swaine, ***webbi*** Swaine)

Diagnosis. Length 3.9–5.3 mm. Reddish brown to black; frons broad between eyes, deeply, broadly, transversely impressed above epistoma, this impression divided by a distinctly elevated median carina, which ends in an arcuate transverse impression; pronotal surface with moderately large, deep, close punctures; elytral punctures deep, very coarse; elytral interspaces scarcely rugose to granulate-punctate; last abdominal sternite (♂) with a wide, shallow groove with longer setae; elytral vestiture sparce, hairlike, becoming more scalelike on declivity.

Hosts. *Pinus* spp.

Distribution (Map 16). Eastern Canada as far west as Manitoba; eastern United States.

Biology. Not investigated.



Maps 14 and 15. Distribution of *Hylurgops* spp. 14, *H. porosus;* 15, *H. reticulatus.*

Hylastes tenuis (Eichhoff) (***criticus*** Eichhoff, ***pusillus*** Blackman, ***minutus*** Blackman)

Diagnosis. Length 2.4–2.9 mm. Dark reddish brown to black; frons convex, transversely impressed above epistoma, impression not divided by a transverse elevated carina (a faint line can sometimes be seen); pronotal surface with large, close punctures; elytral punctures large, close, rather deep; elytral interspaces convex, finely rugose, uniserrately granulate near and on declivity; last abdominal sternite (♂) not especially modified; elytral vestiture long.

Hosts. *Pinus* spp. and *Pseudotsuga menziesii.*

Distribution. Southern British Columbia and possibly southern Ontario; throughout United States.

Biology. Not investigated.

Hylastes macer LeConte (Figs. 62, 106, and 144)

Diagnosis. Length 5.0–6.5 mm. Reddish brown to black; frons convex, distinctly, transversely impressed above epistoma, impression divided by a distinctly elevated, longitudinal carina, which ends in an arcuate transverse impression; pronotal surface with rather small, closely placed, deep punctures, these somewhat irregular in size; elytral punctures rather small, close and deep, smaller on declivity; elytral interspaces finely punctate-reticulate, finely granulate on declivity; last abdominal sternite (♂) broadly impressed in median line with longer setae and finer punctures; elytral vestiture very short and hairlike on disk, densely scaly on declivity.

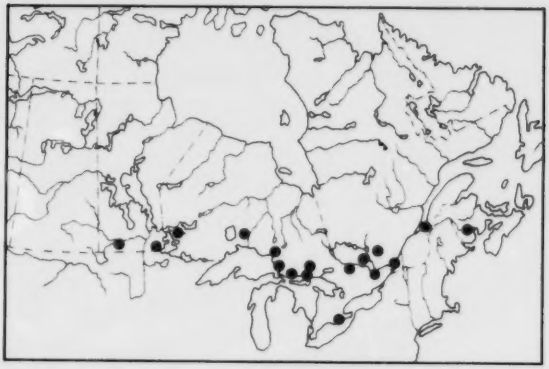
Hosts. *Pinus* spp.; rarely *Pseudotsuga menziesii.*

Distribution (Map 17). Southern British Columbia; western United States.

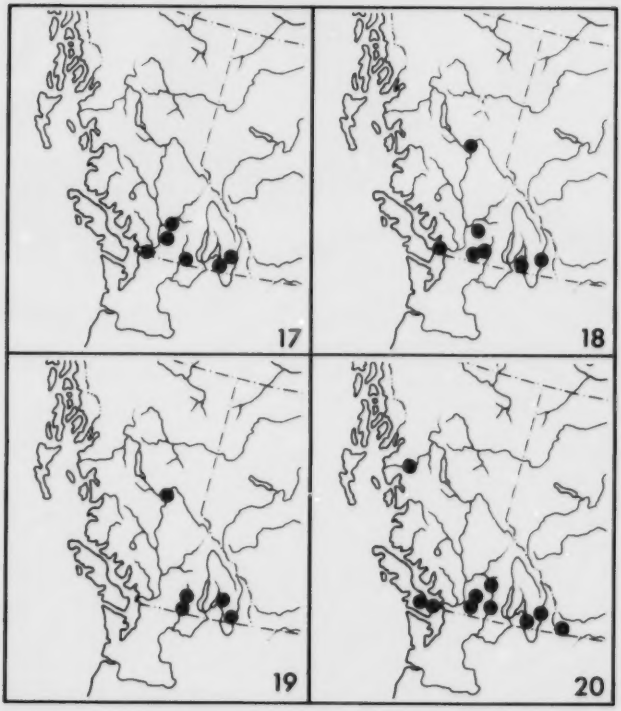
Biology. Not investigated.

Hylastes ruber Swaine

Diagnosis. Length 4.4–5.0 mm. Bright reddish brown; frons convex, shallowly, transversely impressed above epistoma, impression divided by a distinctly elevated, longitudinal carina, this carina more strongly elevated around transverse impression; pronotal surface with moderately large, deep, and close punctures; elytral punctures moderately large, deep; elytral interspaces finely, rather densely rugose, more strongly rugose on declivity; last abdominal sternite (♂) flattened, setae only slightly longer than on female; elytral vestiture very short, hairlike on disk and declivity.



Map 16. Distribution of *Hylastes porculus*.



Maps 17–20. Distribution of *Hylastes* spp. 17, *H. macer*; 18, *H. ruber*; 19, *H. gracilis*; 20, *H. longicollis*.

Hosts. *Pseudotsuga menziesii;* rarely *Pinus ponderosa.*

Distribution (Map 18). Southern British Columbia; western United States.

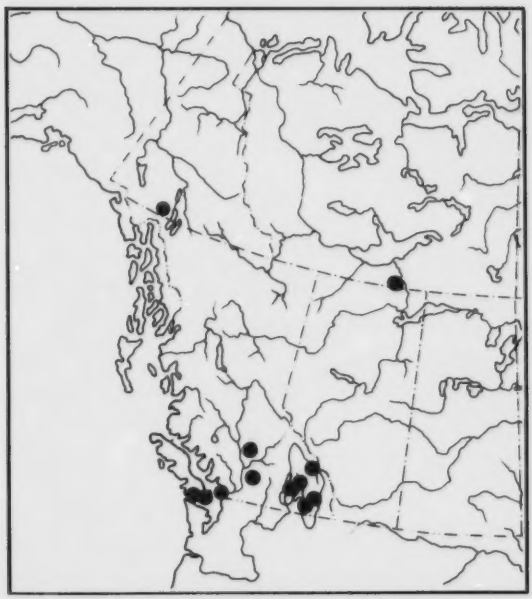
Biology. Not investigated.

Hylastes nigrinus **(Mannerheim) (*yukonis* Fall)**

Diagnosis. Length 4.1–4.9 mm. Dark brown to black, frons narrow between eyes, broadly and deeply impressed on each side above epistoma; median carina usually confined to epistoma but sometimes extending to median pit; pronotal surface with coarse, close, and deep punctures, somewhat irregular in size; elytral punctures coarse, deep, and close, smaller on sides and declivity; elytral interspaces granulate-punctate, more granulate on declivity; last abdominal sternite (♂) broadly impressed in median line with longer setae and finer punctures.

Hosts. *Pseudotsuga menziesii, Pinus* spp., and *Tsuga heterophylla.*

Distribution (Map 21). Southeast Alaska, Yukon Territory, British Columbia; western United States.



Map 21. Distribution of *Hylastes nigrinus.*

Biology. Rudinsky and Zethner-Moller (1967) and Zethner-Moller and Rudinsky (1967).

The biology of this species on Douglas-fir in Oregon is as follows. Adults begin emerging in late March and continue through May; maximum emergence and flight are in late April and early May. The young adults feed on the small roots of dead, old Douglas-fir or the roots of young Douglas-fir, weakened after transplanting, before they actually invade the host. They are attracted to stumps, freshly cut trees, and especially trees killed by the Douglas fir beetle. Whole oleoresin, -pinene, -pinene, and other components of resin have been shown to be attractive to *H. nigrinus*. Adults dig through the sawdust or soil around the host to reach the roots; they also enter at the base of the stem at the soil line.

Egg galleries are initiated by the females; the males enter later and copulation takes place within the gallery as well as outside. Egg galleries are long (about 9 cm) and winding, running parallel to the grain in one direction from the entrance hole. The part close to the entrance hole is almost always angled and wider than the rest of the gallery, and there are usually one or more branches and forked mines. Eggs are laid in distinct, evenly spaced niches about 1–1.5 mm apart. Where eggs are present, the gallery is packed with frass. From 20 to 40 eggs are laid per gallery; the maximum is about 63. There is no reemergence of parent adults.

Larvae feed communally, forming no distinct larval galleries. Pupal chambers are found at all depths in the bark but mostly in the cambial layer. Adult beetles as well as full-grown larvae overwinter in the gallery. Most of the population completes development in 1 year, but some may take 2 years. These overwinter as adults the second year.

Hylastes gracilis LeConte (*nitidus* Swaine)

Diagnosis. Length 3.4–4.3 mm. Reddish brown to black; frons moderately broad with a median, transverse arcuate impression, densely punctured; median carina extending from epistoma to transverse impression; pronotal surface with moderate-sized punctures, much finer and closer in front; elytral punctures moderate, smaller on sides and declivity; elytral interspaces finely rugose-punctate, uniserrately granulate on declivity; last abdominal sternite (♂) distinctly grooved, with the setae more numerous and longer than on other sternites.

Hosts. *Pinus* spp.; rarely *Abies* spp.

Distribution (Map 19). Southern British Columbia; western United States.

Biology. Not investigated.

Hylastes longicollis Swaine

Diagnosis. Length 3.4–4.0 mm. Reddish brown; almost identical with *H. gracilis* except pronotum more elongate, distinctly narrower than elytra; strial punctures coarser than in *H. gracilis;* pubescence longer than in *H. gracilis*.

Hosts. *Pinus* spp.

Distribution (Map 20). Southern British Columbia; western United States.

Biology. Not investigated.

Genus *Dendroctonus* Erichson

Members of this genus are easily recognized by their usually large, stout bodies; their well-developed epistomal process; the subcircular, flattened antennal club having three procurved sutures; and the evenly convex elytral declivity.

Some of the species of this genus are the most destructive tree killers known. Annual losses of about 12.5 million m^3 (5 billion board feet) of sawtimber have resulted from the depredations of these insects. Consequently, the various species have been the subjects of more biological studies than those in any other genus of Scolytidae except possibly *Ips* De Geer.

The genus was revised by Wood (1963).

Key to the species of *Dendroctonus* in Canada and Alaska (Modified from Wood (1963))

1. Frons with a narrow, deep median groove extending from near the epistomal process to the upper level of the eyes; lateral area of frons usually rather strongly protuberant and armed with one or two tubercles; southern British Columbia . . . . . ***brevicomis*** **LeConte**

   Frons without a median groove or lateral elevations; generally distributed 2

2. Declivital interspaces dull, opaque, or shining; if shining, then the punctures all granulate in both sexes with strial punctures distinct and large; epistomal process broad, the distance between eyes not more than 2.2 times the basal width of an eye; episternal area of prothorax coarsely granulate, the punctures obscure or absent 3

   Declivital interspaces smooth and shining, most of the punctures impressed, a few granulate in the female; epistomal process narrow, the distance between eyes three or more times the basal width of an eye; episternal area of prothorax punctate, the granules minute or absent 4

3. Body black to dark brown; body size 3.7–7.5 mm (average 5.5 mm); surface of declivity opaque, usually rugulose, interspaces usually uniseriately granulate and with scattered fine punctures; southern British Columbia . . . . . ***ponderosae*** **Hopkins**

   Body red to reddish brown; body size 5.4–9.0 mm (average 8 mm); surface of declivity shining, interspaces confusedly granulate; transcontinental . . . ***valens*** **LeConte**

4. Declivital striae weakly or not impressed; declivital interspace 1 weakly elevated; epistomal process usually transversely concave, broad 5

   Declivital striae strongly impressed; declivital interspace 1 strongly elevated; epistomal process flat or convex, narrow 7

5. Frons finely granulate between the close, deep punctures (granules sometimes obscure in *murrayanae*); strial punctures on declivity usually minute, usually less than twice as large as those of interstriae 6

Frons smooth and polished, with deep, close punctures, but almost entirely without granules between punctures; strial punctures on declivity rather large, three or more times as large as those of interspaces; transcontinental ..... ***punctatus*** **LeConte**

6. Frons coarsely, distinctly punctured, the granules between punctures usually isolated from one another, often very sparse; from *Pinus* spp. ..... ***murrayanae*** **Hopkins**

Frons very closely and more coarsely granulate, the punctures usually obscure in median area; from *Picea* spp. ..... ***rufipennis*** **(Kirby)**

7. Body smaller, 3.4–5.0 mm; frons moderately protuberant, smooth with deep, coarse punctures; Alaska to Newfoundland; from *Larix laricina* ..... ***simplex*** **LeConte**

Body larger, 4.4–7.0 mm; frons strongly protuberant, irregularly granulate, with fine, deep punctures; southern British Columbia; from *Pseudotsuga menziesii* and (rarely) *Larix* spp. and *Tsuga* spp. ..... ***pseudotsugae*** **Hopkins**

Dendroctonus brevicomis LeConte (***barberi*** Hopkins) (Fig. 179)

Diagnosis. Length 2.5–5.0 mm. Frons convex, with a pair of lateral elevations on median half, separated by a deep groove, surface punctured and subgranulate below eye level; pronotal surface smooth, with fine and shallow punctures; elytral punctures small and shallow; elytral interspaces with abundant, confusedly placed, small crenulations; declivity feebly impressed between striae 1 and 3.

Host. *Pinus ponderosa;* numerous other species of *Pinus* in the United States.

Distribution (Map 22). Southern British Columbia; western United States and northern Mexico.

Biology. Stark and Dahlsten, editors (1970).

The adult female of the western pine beetle, *D. brevicomis*, initiates attack at midbole, just below crown level, boring through the bark at right angles to the stem axis until it reaches the phloem-cambial layer. Selection and attack of uninjured, healthy trees apparently occurs at random, but lightning-struck trees and trees injured by air pollutants, infested by root pathogens, or injured in other ways appear to be more susceptible to attack. Trees less than 30 cm in diameter are seldom attacked. After successful invasion by one or more females, a powerful secondary attractant or pheromone is produced, which causes a mass attack and the entire length of the bole is filled in. The attacking beetles introduce a blue stain fungus, which apparently helps them in overcoming the resistance of the tree.

The color of the foliage in mass-attacked trees changes in a characteristic manner. The normal dark green fades to pale green, gradually changes to lemon yellow, then to straw color, sorrel, and finally dark red. After the tree has been abandoned by the beetle progeny, the foliage slowly turns brownish black and drops off. This sequence of color change is extremely variable and often is not well synchronized with the insect's life cycle.

The egg gallery in the phloem-cambial region is long and winding (Fig. 179). The male joins the female while she is boring in or during the early stages of gallery construction. Egg niches are cut in the wall at more or less symmetrical intervals from 1 to 8 cm apart. From 35 to 60 eggs are laid, one to a niche, separated from the main gallery by a plug of frass. Oviposition may last up to 6 weeks in spring and summer; overwintering females may lay some of their eggs in the fall, and the rest the next spring. Except for a few centimetres near the entrance hole and a few centimetres at the end of the gallery where the male and female are working, the galleries are packed with frass.

Eggs hatch in 2–3 weeks, and the early instar larvae bore at right angles to the parent gallery, in the same plane for about 3 cm. Then, the larvae turn outward into the bark, at right angles to the bole axis. The remainder of the developmental cycle is spent in the bark. In overwintering broods, only larvae, prepupae, and adults overwinter, never pupae. When adults are mature, they bore out of the bark and take flight. There is a diurnal flight periodicity that corresponds roughly with the daily temperature range. The flight capacity is not known, but it is suspected that *D. brevicomis* is capable of flying at least 3 km, and up to 12 km when wind currents are utilized.

The number of generations per year and the length of any generation in a particular locality vary, depending upon climate. In Canada there may be up to two complete generations per year; in southern California there may be between three and four complete generations per year. Because of variability in the length of the attack period and development times, overlapping generations are common and some *D. brevicomis* adults may be in flight at almost any time during the summer and fall.

The western pine beetle is considered by many to be the most destructive forest pest known. In the Pacific Coast states, about 62.5 million m^3 (25 billion board feet) of ponderosa pine sawtimber were lost during 1921–45; losses have been just as high since 1945.

In Canada, losses due to this species have not been as spectacular as those in the United States, because this beetle is found only in a small area of south

Maps 22 and 23. Distribution of *Dendroctonus* spp. 22, *D. brevicomis*; 23, *D. ponderosae*.

central British Columbia. Some damage has occurred in the Okanagan Valley and adjacent regions.

Dendroctonus ponderosae **Hopkins (*monticolae* Hopkins) (Figs. 63, 107, and 145)**

Diagnosis. Length 3.7–7.5 mm. Frons convex, median line narrowly impressed above upper level of eyes, punctate-rugose above eye, subgranulate below; pronotal surface smooth, shining, with small, deep, laterally granulate punctures; elytral punctures small, deep; elytral interspaces with coarse, scattered, transverse crenulations; declivity steep, interspace 2 deeply impressed, striae 2 and 3 curved toward apex; interspaces granulate.

Hosts. *Pinus* spp.

Distribution (Map 23). Southern British Columbia; western United States and northern Mexico.

Biology. Cole and Shepherd (1967), McCambridge and Trostle (1970), and Wood (1963).

Parent adults of the mountain pine beetle usually attack during June, July, and August. They bore through the bark to the phloem-cambial region, turn upward, and excavate egg galleries up to 75 cm or longer. Galleries usually run longitudinally with the stem axis of the tree, but they may be somewhat sinuous when obstructions such as knots or branch stubs are encountered. The nuptial chamber may be offset from the egg gallery to form an extended J pattern.

Beetles are attracted to trees that are already under attack, are overmature with decadent crowns, are suppressed second growth, have been struck by lightning or mechanically injured, are affected by disease, or are freshly killed. The mountain pine beetle is apparently less able to overcome trees having visible oleoresin flow than is the western pine beetle. There is evidence to suggest that as soon as a successful attack by a few beetles has been initiated, an attractant is produced that encourages mass attack. Partial attacks that do not completely kill the tree are fairly common, but trees that have suffered such attacks usually succumb eventually. Pitch tubes or pitch "streamers" are common evidence of attack.

Eggs are deposited along each side of the gallery in individual niches 2–5 cm apart and are tightly packed in with frass as is the entire egg gallery behind the ovipositing female.

When the larvae hatch, they feed in the phloem-cambial region in individual tunnels. These feeding galleries extend 2–14 cm at right angles to the egg gallery. Usually in late fall, the mature larvae excavate a shallow, oval pit for pupation. The brood may overwinter in any stage (except pupae) from young larvae to young adults, depending on the time of attack and the climate.

There is one generation per year throughout most of its range. Two generations and often the beginning of a third may occur in warm climates, at elevations below 2,000 m, south of lat. 40° N.

This is one of the most destructive species in the pine forests of western

North America. Severe economic damage is most common in lodgepole, western white, and ponderosa pine stands. Between 1951 and 1960, some 475,000 m^3 (190 million board feet) of western white, lodgepole, and ponderosa pine were killed in British Columbia.

Dendroctonus valens LeConte

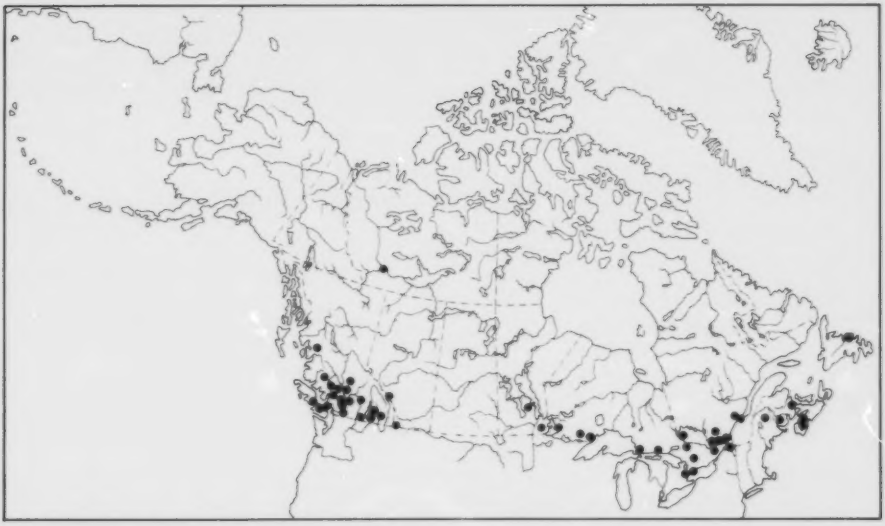
Diagnosis. Length 5.4–9.0 mm. Frons irregularly convex, with a pair of weak protuberances separated by a broad shallow depression, surface punctate; pronotal surface smooth, with close, shallow punctures; elytral punctures small, deep; elytral interspaces with small, abundant crenulations; declivity steep, convex, feebly impressed between striae 1 and 3, granulate.

Hosts. *Pinus* spp.; rarely *Abies concolor*, *Larix laricina*, and *Picea* spp.

Distribution (Map 24). Transcontinental in Canada; Northwest Territories to Guatemala, through the eastern United States but not found in southeastern United States.

Biology. Smith (1971) and Wood (1963).

The red turpentine beetle is attracted by whole oleoresin. Attacks are most common in stumps of freshly cut trees, and injured, weakened, or dying trees. However, apparently healthy trees are often attacked. Attacks may occur up to a height of 6 m on the tree trunk, but are usually concentrated at or near ground level. Flight and attacks of beetles occur throughout the warm season.



Map 24. Distribution of *Dendroctonus valens*.

The female constructs the entrance tunnel and, when she reaches the cambium region, she usually turns upward for a short distance. The shape of the gallery is variable, but is usually linear from 1 to 3 cm wide. Branched galleries and irregular cave-type galleries are common. The gallery is usually packed with characteristic granular reddish frass.

No egg niches are cut. Eggs are deposited along the sides of the galleries, either loose in the frass or in layers of 10–40 or more. Over 100 eggs may be laid per gallery. After oviposition the parent beetles may feed for a time, emerge to initiate new attacks, or die in the gallery.

Eggs hatch in 1–3 weeks depending on the season. The larvae feed gregariously in the phloem tissue, often enlarging the initial gallery and killing a patch of phloem up to 20–30 cm across. The larval period may take from a few months to over a year, depending on the climate of the area.

Mature larvae excavate separate cells in the sapwood or bark, where they pupate. Adults are strong fliers capable of flights up to 16 km or more.

The rate of development of a generation and the number of generations per year varies widely. In Canada 2 years may be required for a generation. In southern latitudes, and at lower elevations, two to three generations may be completed per year. Overlapping generations are typical and beetles may be found in flight throughout the summer.

The red turpentine beetle is not considered to be a destructive species by itself, but it may predispose trees to attack by other scolytids, which in concert with *D. valens* cause the death of trees.

Dendroctonus punctatus LeConte (***johansoni*** Swaine)

Diagnosis. Length 5.4–6.8 mm. Frons convex, protruding slightly at center below middle, punctures close, deep; pronotal surface smooth, shining, punctures fine, irregular, deep and close; elytral punctures large and deep; elytral interspaces with numerous, abundant, confusedly placed crenulations; declivity steep, convex, interspaces smooth, punctate-granulate.

Hosts. *Picea* spp.; less commonly *Larix laricina* and *Pinus* spp.

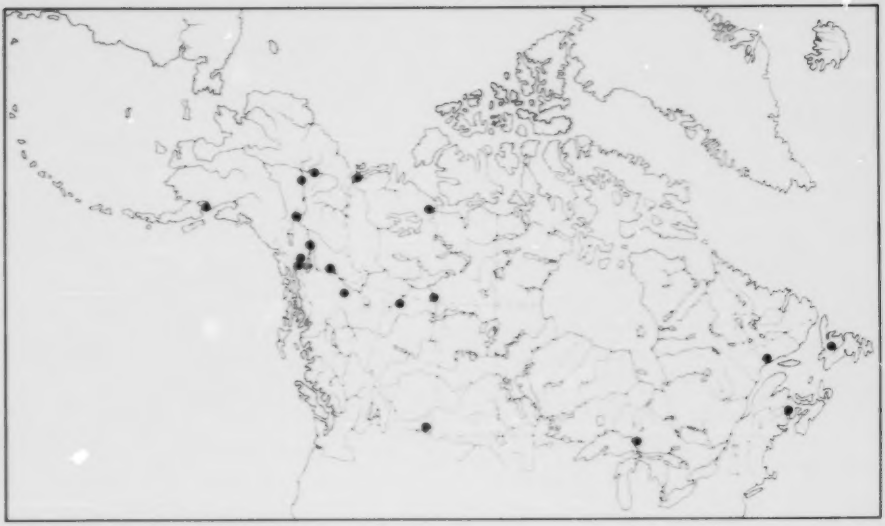
Distribution (Map 25). Transcontinental in Canada; northern United States.

Biology. Wood (1963).

This species has not yet been recognized as an economically important species in Canada, possibly because of competition with the more aggressive *D. rufipennis* and also some of the damage caused by *D. punctatus* may have been masked by other species.

D. punctatus attacks either standing or fallen trees. The lower part of standing trees is evidently attacked first, and it is assumed that the mass attack progresses upward from the ground level.

The egg galleries tend to be vertical or with the grain of the wood, although



Map 25. Distribution of *Dendroctonus punctatus*.

they may be sinuous or otherwise irregular. The maximum length is about 20 cm. From 20 to 50 eggs are deposited in grooves constructed on alternating sides of the gallery, and separated from the main part of the gallery by a partition of frass and boring dust. Females often emerge after laying one batch of eggs, and then they construct a second and even a third set of galleries.

The larvae feed communally, forming a large, flat cavity in the phloem-cambial region. Pupal cells are formed in the frass that fills the larval chamber.

Winter is passed either as adults or partly grown larvae. The generations probably overlap. Flight activity begins in late May or early June and continues until late August. There may be one complete and a partial second generation each year.

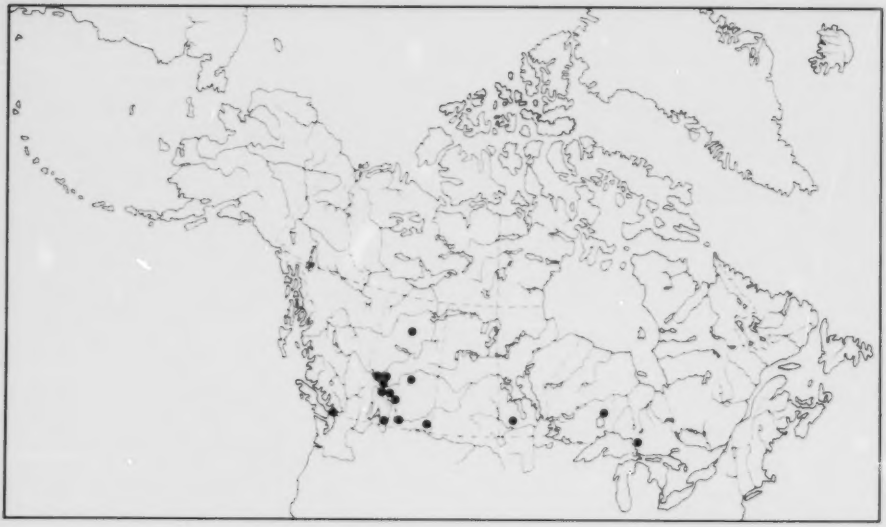
This species is very similar to the European *D. micans* (Kugelann) and, in fact, the two may be the same species.

Dendroctonus murrayanae Hopkins

Diagnosis. Length 5.0–7.3 mm. Frons as in *D. punctatus*, except punctures very close and deep, about half of them with a small rounded granule on lower rim; pronotal surface and elytral punctures and interspaces similar to *D. punctatus*.

Hosts. *Pinus* spp.

Distribution (Map 26). From the Great Lakes area to British Columbia; northern Rocky Mountain states.



Map 26. Distribution of *Dendroctonus murrayanae*.

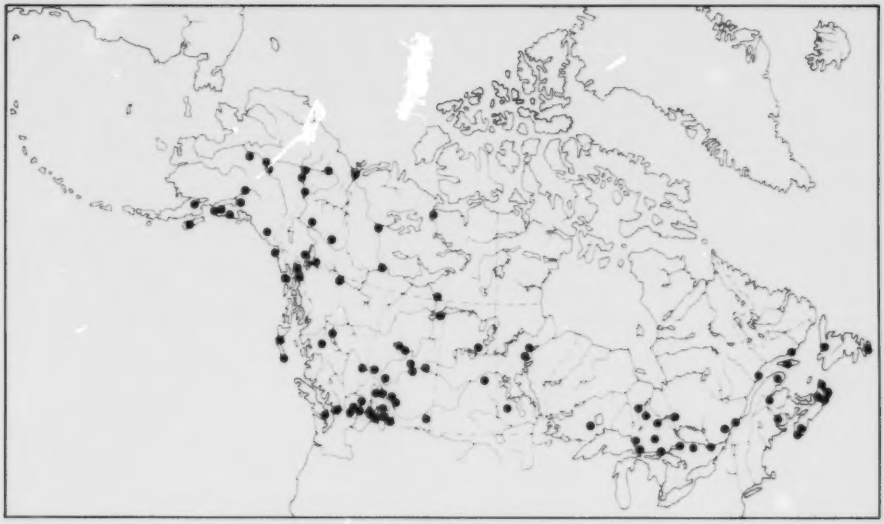
Biology. Wood (1963).

This species, known as the lodgepole pine beetle, attacks stumps, windfalls, and overmature or weakened standing trees. Ordinarily it is not an aggressive species, but it may contribute to outbreaks of the bark beetle more than is commonly believed. Attacks are usually near ground level and in the roots of stumps or standing trees; in windfalls, adults prefer the lower part of the bole.

The egg galleries are irregularly longitudinal, slightly wider than the beetle, with shallow expanded areas along one or both sides. The maximum length is about 20 cm, with an average of 12 cm. The eggs are not laid in niches but are deposited in groups of 20–50 in elongate, expanded areas along the gallery. From one to three groups, sometimes more, occur in each gallery, alternately along the sides. The larvae feed communally first at right angles to the egg gallery, later turning either up or down. At the point of turning, islands of unexcavated phloem are left. Pupation occurs in the frass of the cavity or sometimes at the end of short, independent galleries. The number of generations per year in Canada is not known, but in the northern United States one and part of a second generation is completed.

Dendroctonus rufipennis (Kirby) (***obesus*** Mannerheim, ***similis*** LeConte, ***piceaperda*** Hopkins, ***engelmanni*** Hopkins, ***borealis*** Hopkins)

Diagnosis. Length 4.4–7.0 mm. Frons convex, punctures close, deep, rather fine, almost obscured in median area by fine, abundant granules; pronotal surface smooth, with fine, irregular, close, deep punctures; elytral punctures large, shallow; elytral interspaces with abundant, small, transverse crenulations; declivity steep, convex, interspaces almost smooth, punctate, the median punctures slightly granulate on upper rims.



Map 27. Distribution of *Dendroctonus rufipennis*.

Hosts. *Picea* spp.

Distribution (Map 27). Transcontinental in Canada; eastern and western United States.

Biology. Dyer and Taylor (1968), Grant and Cottrell (1968), and Wood (1963).

Attack periods, length of development, and consequently the number of generations per year vary greatly because of the wide range of this species. A description of the life history in British Columbia follows. The bionomics in Eastern Canada is probably very similar.

Females of the spruce beetle attack first. They prefer windfalls, freshly cut logs, and shaded slash, but standing trees are attacked when populations are high. In prostrate trees, only the underside next to the ground is attacked. In standing trees, the lower third of the bole is preferred and is the first attacked, but attacks may occur up to 20 cm. Continued attack is slow, not showing the sudden mass attack of such species as *D. brevicomis*. Stands over 120 years old are most susceptible.

The female bores into the cambial region, she is joined by the male, and they start excavating the egg gallery. Parent adults may reemerge for a second attack. Galleries are vertical and straight, about 13 cm long (maximum 23 cm). There is usually a bend 1–2 cm above the entrance tunnel. Eggs occasionally are deposited individually in separate niches, but more often they are laid in groups in egg grooves up to 8 cm long. The grooves are formed alternately on both sides of the gallery. The female lays up to 200 eggs.

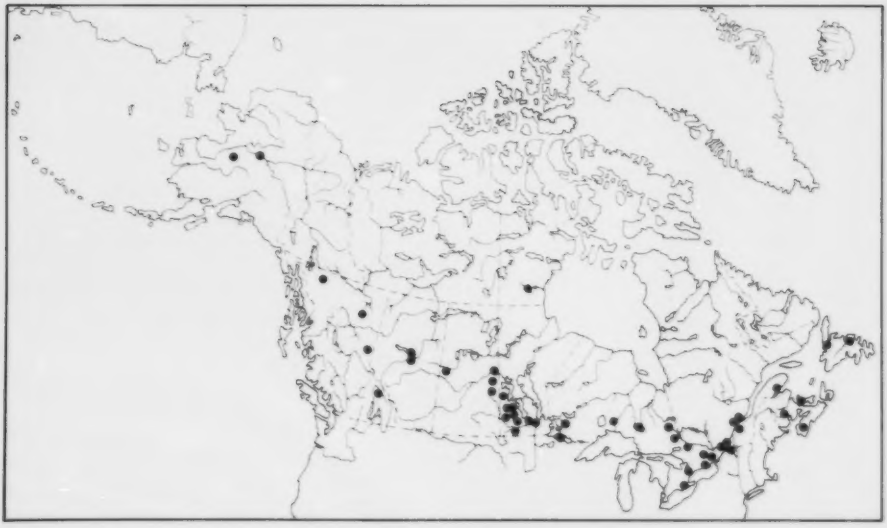
For about the first third of their development, larvae feed communally but then they form individual feeding galleries, which may cross one another. Pupal cells are formed at the ends of larval mines, in previously excavated areas either next to the cambium or entirely in the bark.

D. rufipennis usually has a 2-year life cycle in British Columbia, but some populations may mature in 1–3 years. Regardless of the length of the life cycle, this species must overwinter as an adult before it can attack. This hibernation habit has not been recorded for any other species of *Dendroctonus*.

This species, under the name *engelmanni*, was responsible for tremendous losses of Engelmann spruce in the Rocky Mountain region of the United States from 1948 to 1955. Such outbreaks usually occur when populations increase in large volumes of windthrow or logging slash. This species is the most dangerous forest pest in this intermountain region. Throughout Canada, this species is a serious pest of spruce stands. It is a chronic problem in British Columbia, where some 14 million m^3 (500 million cubic feet) of white spruce were destroyed in the early 1960's, and it has also caused damage in Alberta and Nova Scotia. Local outbreaks have occurred throughout the spruce-growing regions of Canada and Alaska.

Dendroctonus simplex LeConte

Diagnosis. Length 3.4–5.0 mm. Frons convex, with coarse, deep, close punctures; epistomal process flat, overlapping, and nearly flush with epistomal margin; pronotal surface smooth, the punctures coarse, close, and deep; elytral punctures large, deep; elytral interspaces bearing an irregular row of transverse



Map 28. Distribution of *Dendroctonus simplex*.

crenulations; declivity steep, convex; sutural interspace very strongly elevated; punctures coarse, granulate on female.

Host. *Larix laricina.*

Distribution (Map 28). Transcontinental in Canada; northeastern United States.

Biology. Wood (1963).

This species, known as the eastern larch beetle, prefers dying or injured trees and is not considered to be of major economic importance. It has caused up to 10% mortality in some larch stands in the Northwest Territories (Annu. Rep. For. Insect and Dis. Surv. 1969). It also has caused mortality in stands weakened by attacks of the larch sawfly, fire, or flooding.

The egg galleries are vertical, about 20–25 cm long. Eggs are deposited in groups of three to six, or more, in grooves cut along the gallery wall. The larvae construct individual feeding mines, which rarely cross, that eventually expand into irregularly shaped feeding chambers, where pupation and hibernation also take place. Winter is passed as larvae or as young adults, although there is considerable overlap. In Eastern Canada, one generation per year is completed, but in the more northern latitudes, a generation may take 2 years.

Dendroctonus pseudotsugae Hopkins

Diagnosis. Length 4.4–7.0 mm. Frons similar to *D. simplex* except epistomal process wider, surface more coarsely punctured; pronotal surface similar to, but more finely punctured than, *D. simplex;* elytral punctures similar to, but slightly larger and deeper than, *D. simplex;* elytral interspaces similar to *D. simplex;* declivity as in *D. simplex.*

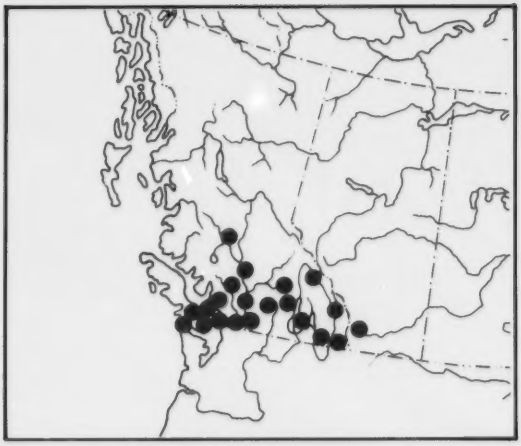
Hosts. *Pseudotsuga menziesii;* rarely *Larix laricina, L. occidentalis,* and *Tsuga heterophylla.*

Distribution (Map 29). Central British Columbia and Alberta; western United States.

Biology. Furniss (1965), Furniss and Orr (1970), Rudinsky (1966), Skovsgaard (1968), Wood (1963), and Wright and Lejeune (1967).

The first flight activity and attacks occur in late April or May. Attacking females chew through the outer bark into the phloem-cambial region, where they excavate the egg galleries. This dispersal flight is oriented toward fresh windthrown, fire-injured, and cut trees, when present. Apparently, the beetles are attracted by fresh oleoresin. Although trees of subnormal physiological condition are preferred, under epidemic conditions and in attractive attack centers, even vigorous trees may be invaded. When concentrations of susceptible material are lacking, beetles tend to be distributed uniformly throughout forest stands.

A second concentration of beetles occurs in attacked trees. The frass produced by attacking females is attractive to other beetles of this species for up



Map 29. Distribution of *Dendroctonus pseudotsugae*.

to 2 weeks. At close range, oleoresin repels the Douglas fir beetle, but the secondary insect-produced attraction is stronger and it masks the repellent action of oleoresin.

The egg galleries are simple, running parallel to the grain of the wood, and are 12–75 cm long (average 20–25 cm). A single male joins the female in the gallery and helps eject the boring dust and frass during initial gallery construction. Later, the frass is packed in the gallery behind the pair. After completion of egg-laying, the beetles may emerge to attack additional trees. The female deposits 6–24 eggs in each groove on alternate sides of the gallery; she lays 20–100 eggs.

Larvae mine out more or less at right angles to the gallery, but they gradually spread out to form a characteristic fan-shaped feeding gallery. They feed in the inner bark but, when they become mature, they may bore into the bark to pupate. Most of this brood overwinter as young adults. Development from egg to adult takes 7–10 weeks, depending on the temperature.

Some of the progeny of the brood from the spring attack may develop by July and emerge to form part of a second or summer attack. However, most of the beetles comprising the second brood are progeny from the attack the previous summer that overwintered as larvae. Thus, the life cycle of the Douglas fir beetle is about 1 year long and includes two overlapping broods produced in each generation. Adults often congregate in hibernating galleries to overwinter. Some adults may live through a second winter.

D. pseudotsugae, the Douglas fir beetle, is the most destructive insect enemy of Douglas-fir. Severe tree-killing has been recorded throughout the range of that tree species. In British Columbia, about 165,000 m^3 (66 million board feet) were killed from 1952 to 1956 in the Nimpkish Valley on Vancouver Island, and about 193,000 m^3 (75 million board feet) from 1953 to 1955 in the Lac La Hache area in the interior. Outbreaks in the inland regions often last several to many

years and may persist until all the susceptible trees in the stand or drainage are destroyed, whereas coastal outbreaks usually are of shorter duration.

Genus *Xylechinus* Chapuis

Members of *Xylechinus* are distinguishable by the somewhat stout, elongate body; the flattened frons, which is divided by an elevated, longitudinal carina; the granulate-punctate pronotal surface, which is covered by narrow, flattened scales; the regular strial rows; and the densely pubescent elytral interspaces, the pubescence on these consisting of recumbent and erect, narrow scales forming a median row.

Key to the species of *Xylechinus* in Canada

1. Eastern species with erect elytral scales longer, narrower, not broadened at tip ..... ***americanus*** **Blackman**

   Western species with erect elytral scales shorter, broader, broadened at tip ..... ***montanus*** **Blackman**

Xylechinus americanus Blackman

Diagnosis. Length 2.2–2.4 mm. Frons granulate-punctate, bearing a weak, longitudinal median carina; pronotal surface densely covered with narrow, flattened, scalelike setae; elytral punctures large, deeply impressed; elytral interspaces granulate, clothed with flattened, scalelike setae, the median setae longer than others, forming an erect row in each interspace; declivity unmodified.

Hosts. *Picea* spp. and *Pinus* spp.

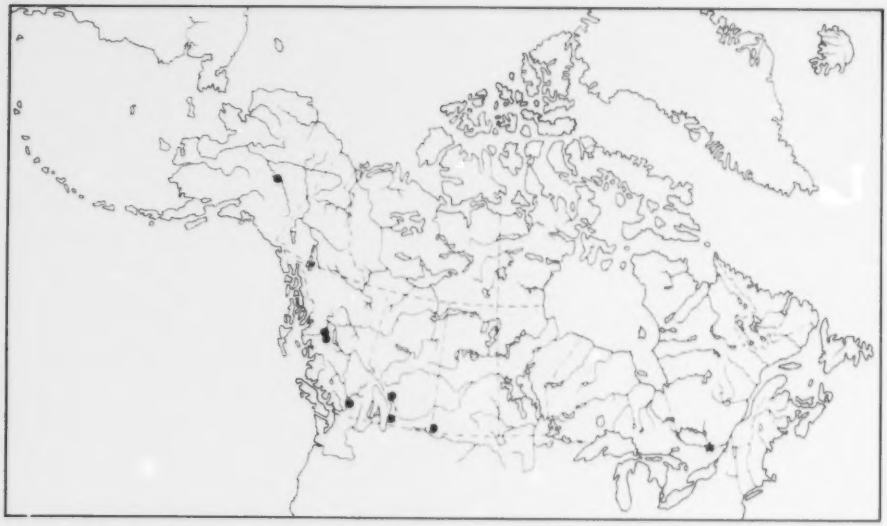
Distribution (Map 30). Eastern Canada; northeastern United States.

Biology. Chamberlin (1939).

Very little is known about the biology of this species. The adults attack small, weakened, dying, usually suppressed spruce trees. The entrance tunnel leads into an irregular central chamber from which two to four egg galleries extend horizontally across the grain of the wood. Each egg gallery contains 10–30 eggs, each placed singly in a niche.

Xylechinus montanus Blackman (Figs. 65, 109, and 147)

Diagnosis. Length 2.2–2.7 mm. Frons as in *X. americanus;* pronotal surface as in *X. americanus* except setae slightly shorter; elytra as in *X. americanus* except median row of interstrial scales shorter, broader, broadened at apex, and recumbent scales smaller.



Map 30. Distribution of *Xylechinus americanus* (★) and *X. montanus* (●).

Hosts. Chiefly from *Picea* spp. and *Abies lasiocarpa;* also *Larix occidentalis.*

Distribution (Map 30). Southern Saskatchewan to British Columbia; western United States.

Biology. Not investigated, but it is considered to be very similar to that of *X. americanus.*

Genus *Pseudohylesinus* Swaine

This genus is closely related to *Xylechinus* Chapuis, but may be distinguished by the 7-segmented antennal funicle and the lack of erect interstrial scales. Other distinguishing characteristics are the scale covering of the body, the hairlike interstrial setae, and the arcuately impressed frons. It is the only genus in North America with a combination of recumbent scales and erect hairlike setae.

This genus was revised by Bright (1969).

Key to the species of *Pseudohylesinus* in Canada and Alaska (Modified from Bright (1969))

1. Frons about as long as wide; antennal club with segment 1 equal to or slightly longer than segment 2; body more slender, more than 2.2 times longer than wide 2

Frons longer than wide; antennal club with segment 1 longer than segment 2, sometimes as long as segments 2 and 3; body stout, usually less than 2.2 times longer than wide, except *P. granulatus* 4

2. Elytral bases with serrations high, sharp, and prominent, more pronounced at sides; interspace 9 strongly elevated and distinctly serrate; less than 3.5 mm long; parent gallery longitudinal ..... ***nebulosus*** **(LeConte)**

Elytral bases with low, blunt serrations; interspace 9 not strongly elevated or serrate; more than 3.5 mm long; parent gallery transverse 3

3. Color pattern consisting of very light brown and white scales, the white scales not arranged in patches ..... ***dispar dispar*** **Blackman**

Color pattern consisting of predominantly black scales with scattered patches of white scales ..... ***dispar pullatus*** **Blackman**

4. Larger, up to 5.5 mm long; body more elongate, 2.4 times longer than wide; pronotum and frons strongly granulate-punctate; elytral striae about as wide as interspaces ..... ***granulatus*** **(LeConte)**

Smaller, less than 4.6 mm long; body stout, less than 2.2 times longer than wide; frons not strongly granulate-punctate; elytral striae narrower than interspaces 5

5. Pronotal scales of female hairlike, those of male slender; striae wider, interspaces appearing convex; interstrial setae of females shorter than width of interspace 6

Pronotal scales of female elongate-oval, those of male broad-oval to nearly circular; elytral striae narrow and interspaces flat; interstrial setae longer than width of interspace in both sexes 7

6. Pronotal scales of male slender, some nearly hairlike; elytral scales of female narrow, hairlike on disk; elytral striae narrower than interspaces; chiefly from *Tsuga* spp. ..... ***tsugae*** **Swaine**

Pronotal scales of male broad, none hairlike; elytral striae nearly as wide as interspaces; chiefly from *Abies* spp. ..... ***nobilis*** **Swaine**

7. Frons with arcuate impression not distinct in either sex; frons of male broad (0.51–0.57 mm); elytral scales of female nearly circular on disk ..... ***grandis*** **Swaine**

Frons with arcuate impression deep and distinct in both sexes; frons of male narrower; elytral scales of female longer than wide on disk 8

8. Frons of male broader (0.48–0.55 mm); body 2.4–3.4 mm long; from Sitka spruce ..... ***sitchensis*** **Swaine**

Frons of male narrower (0.32–0.43 mm); body 2.6–3.3 mm long; from coastal pines ..... ***sericeus*** **(Mannerheim)**

Pseudohylesinus nebulosus (LeConte)

Diagnosis. Length 2.3–2.9 mm. Frons as long as wide, surface closely punctured; pronotal vestiture consisting of short, erect, scattered hairlike setae and numerous, finely divided, recumbent scales; crenulations on elytral bases larger and sharper on sides; vestiture on elytra of numerous circular scales forming a variegated color pattern; declivity convex, interspaces 1 and 3 slightly elevated and weakly serrate.

Hosts. Chiefly *Pseudotsuga menziesii;* also *Abies* spp., *Picea* spp., and *Tsuga* spp.

Distribution (Map 31). Southern half of British Columbia and western Alberta; western United States.

Biology. Bright (1969).

Attack is usually confined to thin-barked slash of saplings, poles or limbs, and tops of large trees. This species is capable of killing trees that are small in diameter, suppressed or weakened, and saplings and tops of live, apparently healthy, Douglas-fir. This species is one of the earliest to attack trees in spring. Attacks begin as early as May 5 and continue throughout May. Later, the Douglas fir beetle, *Dendroctonus pseudotsugae*, usually attacks the same trees. Often the population of *P. nebulosus* is so high that it inhibits establishment by the Douglas fir beetles.

Attacking adults bore through the cambium, where an enlarged nuptial chamber is formed. The beetles work in pairs (monogamous) to excavate a short (2–5 cm) longitudinal egg gallery, which does not score the sapwood. The location of the egg gallery and the reddish boring dust distinguish *P. nebulosus* from *Scolytus unispinosus*, whose gallery is similar. Eggs are laid singly in niches cut on both sides of the gallery at intervals of 1–1.5 cm. Females lay a maximum of 40 eggs; the average is about 18. After oviposition, the parent adults often emerge in June, but they do not attack again; apparently, they die soon after emergence.

The larvae hatch in about 2 weeks. They mine for a short distance at right angles to the egg gallery and then turn up or down. The feeding gallery is usually about 2.3 cm long. The larvae develop to maturity in about 41 days. Late-instar larvae bore into the inner bark and prepare a pupal cell, which is usually not visible from the inside bark surface. The pupal stage lasts about 8 days.

Teneral adults emerge as early as July 26 in some warmer areas, but usually adults emerge from August 15 to September 22, the peak being about August 27. Maturation feeding, which is apparently necessary, may cause considerable damage. This feeding is in healthy Douglas-fir twigs of any age. The feeding adults excavate short, irregular galleries that may cause the twigs to break off, or, at best, callus or canker growth forms over the feeding area. More often, feeding niches and galleries up to 2.5 cm long are cut into the bark. As many as four adults have been found in one gallery. These feeding niches are also used as overwintering sites and some may be extended as egg galleries the following spring.

One generation per year is produced in interior British Columbia.

Pseudohylesinus dispar dispar Blackman

Diagnosis. Length 2.8–4.0 mm. Frons as long as wide, surface finely, closely punctured below arcuate impression, more coarsely punctured above; pronotal vestiture consisting of erect, hairlike setae and numerous circular to suboval, recumbent scales; crenulations on elytral bases blunt, overlapping, all the same size; vestiture on elytra consisting of light to dark brown and white broad, suboval scales forming a variegated color pattern; declivity convex, interspaces 1 and 3 weakly elevated, weakly serrate.

Hosts. *Abies* spp.

Distribution. Southern British Columbia (known only from Salt Springs, B.C.); Washington to California.

Biology. Bright (1969).

Galleries of this species are usually constructed in the bole and large limbs of the host tree. They are transverse and 4.8–11.7 cm long, the average is 7.7 cm. About 57 eggs are laid in each gallery, the maximum is 72.

Pseudohylesinus dispar pullatus Blackman

Diagnosis. Length 2.8–4.0 mm. Very similar to *P. d. dispar* but differing in color pattern (*see* key to species).

Hosts. *Abies* spp.

Distribution. Southern British Columbia (known from Cowitchan Lake, B.C., collected in flight); Washington and Oregon.

Biology. Bright (1969).

Galleries, site of attack, and other details of biology are very similar to *P. d. dispar*.

Pseudohylesinus granulatus (LeConte)

Diagnosis. Length 4.1–5.5 mm. Frons slightly longer than wide, surface strongly granulate-punctate; pronotal vestiture of sparse, narrow, flat recumbent scales and erect, short hairlike setae; crenulations on elytral bases low, blunt; vestiture on elytra consisting of narrow, recumbent scales arranged in various color patterns; declivity convex, unmodified.

Hosts. *Abies* spp.

Distribution (Map 32). Southern half of British Columbia; Washington to California east to Idaho.

Biology. Bright (1969).

This species commonly attacks windthrown, felled, injured, suppressed trees, poles, and saplings in dense stands. However, extensive attack and killing of mature silver fir can occur.

Attack by this species characteristically occurs in the basal part of the tree from several centimeters below ground level up to about 5 metres above ground. It usually attacks at the same time as *P. grandis* attacks the upper portions of the tree. It usually takes more than 1 year of attack to kill a mature tree. Sometimes attacks are in patches, and do not girdle the tree. Trees may recover from scattered attacks, but more often recurrent attacks over a few years eventually kill them. Brown-stain fungi introduced by the beetles apparently aid in

overcoming tree resistance. The foliage of dying trees passes through characteristic color changes in a pattern followed by most trees killed by bark beetles.

There are two types of attack. In late May or early June, overwintering adults emerge and make egg-laying attacks. In late July or early August some of these reemerge, construct more galleries, and lay a second batch of eggs. The second type occurs in August when new adults emerge and make hibernating attacks. They select *Abies* bark and bore nearly straight galleries, 6–15 mm long into the bark but not to the cambium. As many as four may enter the same hole and make separate niches in the bark. These hibernating attacks are concentrated from near the ground up to about 2.5 m in trees within 25 m of the forest edge. Apparently none hibernate in the ground. It is these adults emerging in the spring that make the egg-laying attack.

The entrance holes of the beetle are inconspicuous because the beetles bore in bark crevices and under bark scales, mosses, and lichens. The reddish brown boring dust from the entrance hole may form a conspicuous ring around the base of the tree.

The egg gallery is excavated in the phloem-cambium region at right angles to the stem axis. The length varies from 2 to 18 cm. The eggs are laid in niches cut in both sides of the gallery.

The eggs hatch in 10–14 days and the larvae mine at right angles to the egg gallery, usually following the grain of the wood. The larval mines are parallel at first, but then they diverge and wander, often crossing as the larvae grow. The larval stage lasts 12–14 months; feeding stops during the winter. Due to overlapping generations, both the larvae of one generation and the hibernating adults of another are present at the same time. Mature larvae construct pupal cells in July in the inner bark, and adults start to emerge in August.

This species and *P. grandis* are both commonly called silver fir beetles. Although normally not aggressive species, they can become destructive in mature and overmature stands of Pacific silver fir.

Pseudohylesinus tsugae Swaine (***obesus*** Swaine, ***keeni*** Blackman, ***similis*** Blackman)

Diagnosis. Length 3.3–4.3 mm. Frons slightly longer than wide, surface closely punctate, finely granulate; pronotal vestiture consisting of short, recumbent, hairlike scales, devoid of erect setae; crenulations on elytral bases low, blunt; vestiture on elytra consisting of numerous elongate scales 2–4 times longer than wide, forming an irregular color pattern; declivity convex, unmodified.

Hosts. Chiefly *Tsuga* spp.; also *Abies* spp.

Distribution (Map 33). Southeastern Alaska and British Columbia; Washington to northern California.

Biology. Bright (1969) and McGhehey and Nagel (1969).

Attacks by this bark beetle extend from early May to late August. The beetles prefer stumps of recently cut trees and fresh slash for establishing their brood, but maturation feeding does occur in live standing trees. Attacks occur from ground level to the upper bole just below live crown level or up to about 9 m. Adults usually reemerge and make a second attack before they die.

Females initiate the attack and are joined by the male just before or during entrance. Copulation takes place on the bark or in a nuptial chamber excavated just inside the bark. The beetles work in pairs to construct a transverse egg gallery 19–75 mm long, the average is 42 mm. The gallery may extend in one direction, or both, from the entrance hole. The sapwood is scored to various depths, up to 1 mm.

The eggs are laid in niches about 0.5 mm apart on both sides of the gallery. Each gallery contains about 30 eggs. The eggs may be found from May through August; the incubation period is about 30 days.

The larvae mine at right angles to the parent gallery, just scoring the sapwood. Under crowded conditions, late-instar larvae may reverse direction. Larvae in stumps may mine into the upper roots, often pupating 10 cm beneath ground level. The larval mines may reach 26 cm in length. The larval stage is from June to May of the following year, hibernation takes place in almost any larval stage, and pupation begins in April and is completed by mid-July. From 12 to 17 months is required to complete one generation.

The females feed on the bark of standing trees before sexual maturity. The feeding galleries extend 5–8 mm into the bark and are abandoned after 3–11 days. Adults that are late emerging may overwinter in these maturation feeding galleries. If the gallery is for feeding only, males are not present, but if it is used as a hibernation site then males often join the females.

Pseudohylesinus nobilis Swaine (***furnissi*** Blackman)

Diagnosis. Length 2.7–4.2 mm. Frons slightly longer than wide, surface coarsely, roughly, closely punctured; pronotal vestiture consisting of erect hairs scattered over surface and numerous short, broad, recumbent scales (♂) or setae completely hairlike with no trace of wide scales on lateral margin (♀); crenulations on elytral bases small, blunt; vestiture on elytra consisting of numerous, oval, recumbent scales, about twice as long as wide, slightly smaller on female; declivity convex, unmodified.

Hosts. *Abies* spp., especially *A. amabilis* and *A. grandis*.

Distribution. Southern British Columbia (Gold River); Washington and Oregon.

Biology. Bright (1969).

The galleries are most often transverse, but some variation has been noted. The galleries are about 3.0–8.4 mm long and may be found in the bole and the larger limbs.

Pseudohylesinus grandis Swaine (Figs. 110 and 148)

Diagnosis. Length 2.7–3.9 mm. Frons slightly longer than wide, surface coarsely punctured; pronotal vestiture consisting of numerous broad, elongate, recumbent scales and short, erect hairs; crenulations on elytral bases small, blunt; vestiture on elytra consisting of numerous, flat, circular (♂) or elongate (♀) scales and erect hairs; declivity convex, unmodified.

Hosts. *Abies* spp.; also *Pseudotsuga menziesii* and *Tsuga heterophylla.*

Distribution (Map 34). Southeast Alaska and coastal British Columbia; along the coast from Washington to California.

Biology. Bright (1969) and McGhehey and Nagel (1969).

P. grandis attacks are usually associated with *P. granulatus;* the biologies of the two species are very similar. The main difference is that *P. grandis* attacks along the entire bole of its hosts though mainly in the upper parts and branches, whereas *P. granulatus* attacks mainly the lower bole.

The development time of both species depends to a large extent upon temperature. Because attacks are spread out over long periods, almost any stage of either species may be present at any particular time. However, the development time of *P. grandis* is usually less than that of *P. granulatus.* Attacks in early spring yield brood that completes development to teneral adults by fall. These adults overwinter in hibernation niches in the bark, and they attack the following year. Thus, the complete cycle may be completed in 12 months, rather than the 24 months reported for *P. granulatus.*

Pseudohylesinus sitchensis Swaine

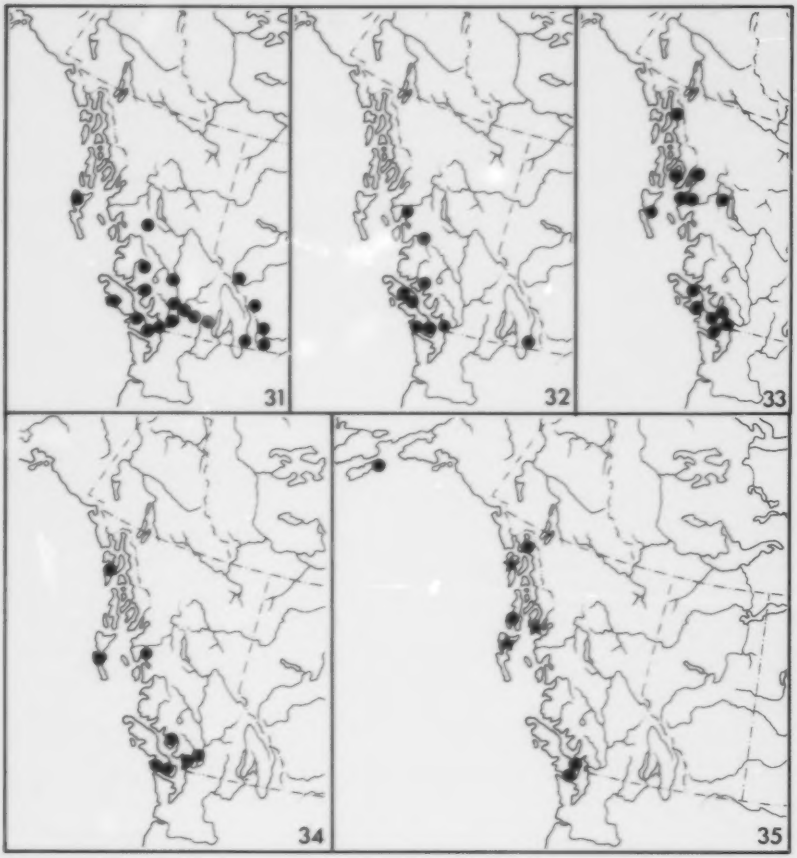
Diagnosis. Length 2.9–3.5 mm. Frons distinctly longer than wide, surface coarsely punctured; pronotal vestiture consisting of short, erect hairs and numerous circular (♂) or elongate (♀) recumbent scales; crenulations on elytral bases blunt, separate; vestiture on elytra consisting of elongate, recumbent scales arranged in various patterns; declivity convex, unmodified.

Host. *Picea sitchensis.*

Distribution (Map 35). Southeast Alaska, Kodiak Island, coastal British Columbia; along the coast from Washington to central California.

Biology. Bright (1969).

No details of the biology of this species are available other than the gallery pattern. The galleries are 1.8–3.0 cm long and run parallel to the stem axis.



Maps 31–35. Distribution of *Pseudohylesinus* spp. 31, *P. nebulosus*; 32, *P. granulatus*; 33, *P. tsugae*; 34, *P. grandis*; 35, *P. sitchensis* (●) and *P. sericeus* (★).

Pseudohylesinus sericeus (Mannerheim) (***pini*** Wood)

Diagnosis. Length 2.4–2.9 mm. Frons distinctly longer than wide, surface finely, closely punctate, finely granulate; pronotal vestiture consisting of short, erect hairs and nearly circular (♂) to elongate (♀) scales; vestiture on elytra consisting of numerous circular (♂) or elongate (♀) scales and erect interstrial hairs; declivity convex, unmodified.

Host. *Pinus contorta.*

Distribution (Map 35). Southeast Alaska, coastal British Columbia; along the coast from Washington to central California.

Biology. Bright (1969).

The details of the biology of this species are unknown except for the gallery pattern. The parental gallery is very similar to that of *P. sitchensis* except that the longitudinal gallery of *P. sericeus* almost invariably shows a pronounced curve or hook at the base of the entrance hole. This hook may be enlarged to serve as a nuptial chamber.

Genus *Alniphagus* Swaine

Members of *Alniphagus* are most easily distinguishable by the widely separated fore coxae, the 7-segmented antennal funicle, the conical, slightly flattened antennal club, the erect asperities on the lateral portions of the pronotum, and the elevated first, third, and alternate declivital interspaces.

Specimens of this genus are found in various western species of *Alnus*.

Key to the species of *Alniphagus* in Canada

1. Body larger, 2.6–3.2 mm long; pubescence on elytral interspaces very short, less than half as long as interstrial width; declivital interspaces 1 and 3 distinctly elevated, granules large, prominent ..... ***aspericollis*** **(LeConte)**

Body smaller, 2.1–2.8 mm long; pubescence on elytral interspaces long, at least half or greater than half the interstrial width; declivital interspaces 1 and 3 weakly elevated, granules very small, inconspicuous ..... ***hirsutus*** **Schedl**

Alniphagus aspericollis (LeConte) (Figs. 66, 112, and 150)

Diagnosis. Length 2.6–3.2 mm. Frons broad, convex or flattened, transversely impressed above epistoma; asperities on lateral portion of pronotum rather large, blunt; strial punctures medium in size; elytral interspaces 1.5–2 times wider than striae; declivital interspaces 1, 3, and alternate interspaces distinctly elevated, with large, acute granules; pubescence short, sparse.

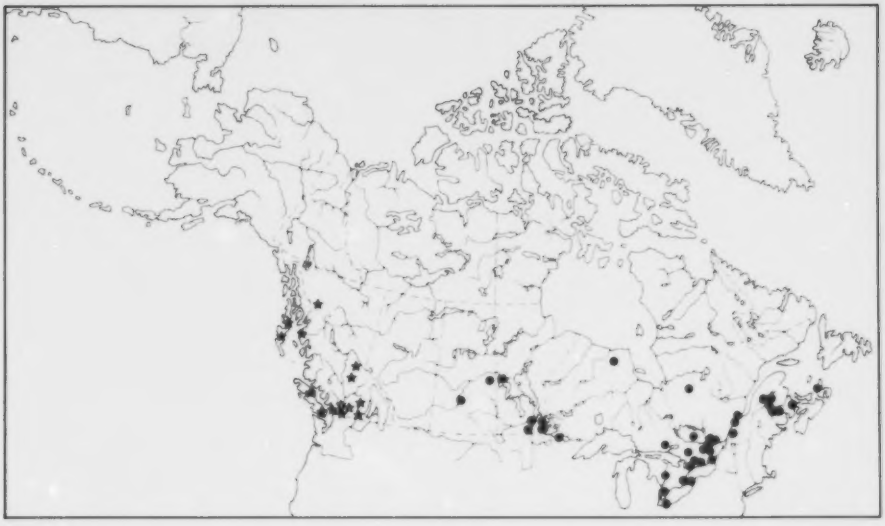
Hosts. *Alnus* spp.

Distribution (Map 36). Southeast Alaska and British Columbia; Washington to southern California.

Biology. Borden (1969).

Adults of *A. aspericollis* may be found throughout the year, but there are only two main flight periods, May and from mid-July to August. Attacks are made on trees weakened by other agents and on slash caused by windthrow, snow breakage, or logging. Trees of all ages may be attacked; the entire tree may be killed or only portions of the stem.

The female initiates the attack and is joined soon after by the male,



Map 36. Distribution of *Alniphagus aspericollis* (★), *A. hirsutus* (◎), and *Hylurgopinus rufipes* (●).

suggesting the presence of a sex attractant. Entrance holes are found under lichens, in bark crevices, at the base of branches, and very often near wounds on the stem. Externally, the entrance hole is bordered by a tightly packed rim of frass and the bark surrounding each hole becomes darkly stained.

Egg galleries are constructed in the phloem-cambial region, scoring the sapwood lightly. Four gallery patterns have been observed. The most common is an elongate type, extending up or down the bole about 8 cm. The other patterns include a wide, irregularly shaped somewhat cavelike type; a two-branched form with egg tunnels extending up and down the bole; and a V-shaped type with two branches extending in the same direction facing up or down the bole. Eggs are laid on both sides of the gallery in niches about 1 mm apart. Up to 69 eggs per gallery have been reported. Parent adults often reemerge after oviposition and presumably make additional attacks.

The larvae mine at right angles to the egg gallery for a short distance, then turn and mine with the grain, leaving upright septa between their mines in the inner bark. Like most scolytids, the larvae pack the gallery behind them with frass. The mature larva constructs a chamber in the inner bark for pupation.

A. aspericollis produces two generations per year in British Columbia. The first main attack is in early May and the second from mid-July to early August. However, fresh attacks may occur throughout the growing season, the result of reemerging parent adults and variations in development time.

Overwintering of the second generation occurs in at least three life stages. Brood adults emerge in early September and fly to healthy trees, where they construct hibernation chambers in the bark. These chambers may have numerous fingerlike projections extending up or down from a larger center, or

they may be short, straight galleries; they do not contact the wood. That portion of the second-generation brood that does not mature overwinters as a late-instar larva, pupa, or callow adult.

Alniphagus hirsutus Schedl

Diagnosis. Length 2.1–2.8 mm. Frons broad, convex, rather strongly, transversely impressed above epistoma; asperities on lateral portion of pronotum fairly small except on anterolateral angles; strial punctures large; elytral interspaces narrower than striae; declivital interspaces 1, 3, and alternate interspaces weakly elevated, with very small, sparse granules; pubescence abundant, long.

Hosts. *Alnus* spp.

Distribution (Map 36). Southern British Columbia; Washington to northern California.

Biology. Not investigated, but probably similar to *A. aspericollis*.

Genus *Hylurgopinus* Swaine

Hylurgopinus rufipes (Eichhoff) (Figs. 64, 108, and 146)

Diagnosis. Length 2.4–3.0 mm. Frons convex, weakly impressed at middle and above epistomal margin, surface strongly punctate; pronotal surface strongly punctured, the punctures very close and deep; elytral interspaces narrow, with small, erect rugosities; declivity convex, similar to disk except interstrial rugosities changing to small, acute granules.

Hosts. *Ulmus* spp.; rarely *Fraxinus* spp., *Prunus* spp., and *Tilia* spp.

Distribution (Map 36). New Brunswick to Manitoba; eastern United States west to Kansas.

Biology. Davidson et al. (1964), Thompson and Matthysse (1972), and Whitten and Reeks (1967).

The native elm bark beetle, *H. rufipes*, spends the winter in either the larval or adult stages. The overwintering adults emerge during May and fly to living trees, where they feed in the bark. A short while later, the adults move to dead or dying trees, or recently dead limbs of at least 5 cm in diameter. Entrance holes are constructed under bark scales or in crevices, and the tunnels penetrate directly into the cambial area.

The gallery pattern is biramous, having two arms extending away from the entrance hole in a transverse direction. These egg galleries may be constructed entirely in the bark, or they may score the wood slightly. Eggs are laid along the gallery on both sides, and the larvae mine away from the egg gallery, usually following the grain of the wood. The larval period may be as short as 29 days,

but the average is 40–50 days. Five or six instars are the rule. Pupation occurs in cells at the end of the larval mines and lasts 8–12 days. In Canada, there may be only one generation per year or one and a partial second.

When the adults emerge from elms dying of the Dutch elm disease, they often carry the spores of the disease-causing fungus on their bodies. As the adults bore into healthy elms to feed or hibernate some of the spores rub off and innoculate the tree with the disease-causing organism. This species and *Scolytus multistriatus* are the principle vectors of the Dutch elm disease.

Genus *Leperisinus* Reitter

Members of *Leperisinus* are distinguishable by the densely scaly elytra and pronotum, the presence of scattered asperities on the lateral areas of the pronotum, the deeply impressed elytral striae, and the other characters given in the key to the genera.

Key to the species of *Leperisinus* in Canada

1. Body 3.5–4.0 mm long; pronotal asperities very small, not longer than surrounding scales; elytral interspaces coarsely rugose ..... ***pruinosus*** **(Eichhoff)**

   Body less than 3.5 mm long; pronotal asperities strongly developed, acute, longer than surrounding scales; elytral interspaces not coarsely rugose 2

2. Declivital interspaces 4–6 usually ending together at a common point on posterior-lateral portion of elytra, interspace 7 usually continuing to and joining interspace 9; declivital striae deeply impressed; antennal club with 3 distinctly visible sutures, the third suture strongly angulate ..... ***aculeatus*** **(Say)**

   Declivital interspaces 4–8 ending together at a common point on posterior-lateral portion of elytra; declivital striae not deeply impressed (except *fasciatus*); antennal club with 2 distinctly visible sutures, the third suture, if visible, transverse to weakly arcuate 3

3. Scales black and white to yellowish white; dorsal surface of pronotum with two transverse patches of white setae on pronotal base on each side of median line; median portion of anterior pronotal margin devoid of asperities .. ***fasciatus*** **(LeConte)**

   Scales light to dark brown and white to yellowish white; median dorsal surface of pronotum usually with a dark diamond-shaped patch of setae; median portion of anterior pronotal margin usually bearing asperities, these asperities usually smaller than those on lateral portion of pronotal margin 4

4. Body 2.0–2.6 mm long; carina on female frons weakly elevated or absent; male frons flattened; sutural interspace of male not elevated; scales on declivital interspaces of male all of equal or nearly equal size ..... ***criddlei*** **Swaine**

   Body 2.4–3.0 mm long; carina on female frons strongly elevated, almost toothlike; male frons strongly concave; sutural interspace of male strongly elevated; median row of scales on declivital interspaces (except second) of male erect, much larger than other recumbent scales ..... ***californicus*** **Swaine**

Leperisinus pruinosus (Eichhoff)

Diagnosis. Length 3.5–4.0 mm. Frons convex (♀) to flattened (♂), more strongly, transversely impressed above epistoma, surface dull, punctate, densely pubescent; pronotal asperities very poorly developed; suture 3 of antennal club moderately arcuate; pronotal surface bearing large, close, deep punctures; elytral interspaces strongly rugose, a median row of rugosities extends above scale covering; vestiture consisting of light and dark scales arranged in a variegated pattern.

Hosts. *Fraxinus* spp.

Distribution. Not recorded from Canada, but probably found in southern Ontario; known from the eastern United States, north to Michigan and Pennsylvania.

Biology. Not investigated.

Leperisinus aculeatus (Say) (***cinereus*** Swaine)

Diagnosis. Length 2.1–3.0 mm. Frons convex (♀) or flattened (♂), slightly impressed above epistoma, surface dull, punctate-reticulate, with a faint longitudinal carina, densely pubescent; pronotal asperities prominent, forming an arcuate line from the lateral areas to the anterior pronotal margin, then to the opposite lateral area; suture 3 of antennal club strongly angulate; pronotal surface bearing scattered granules; elytral interspaces more finely rugose, a median row of elevated rugosities barely discernible; vestiture consisting of white and dark brown or dark reddish brown scales arranged in a variable, variegated pattern.

Hosts. *Fraxinus* spp.

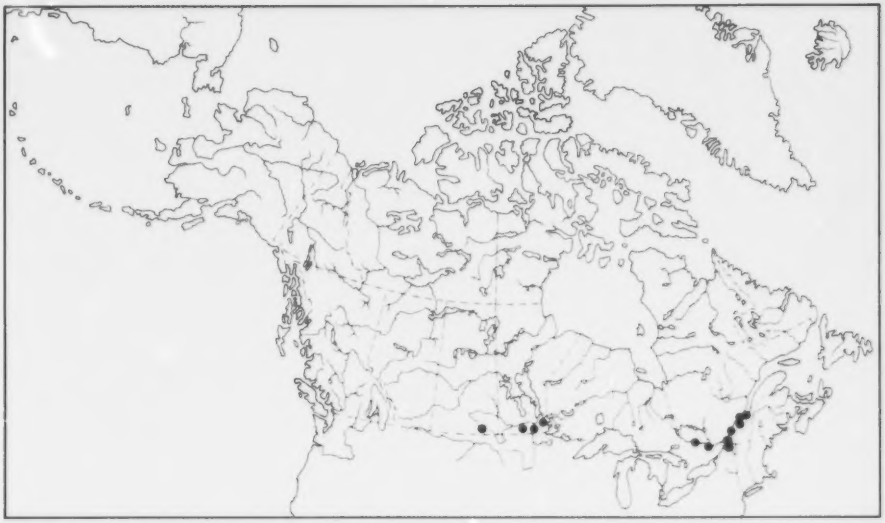
Distribution (Map 37). Eastern Canada west to Saskatchewan; eastern United States.

Biology. Baker (1972).

Adults of the eastern ash bark beetle, *L. aculeatus*, overwinter in tunnels in the bark of living or felled trees. They emerge in the spring and fly to the trunks or limbs of recently felled, dying, or seriously weakened trees. Egg galleries are constructed between the bark and the wood, both of which are deeply scored. The galleries are biramous and transverse, the two arms being connected by a short tunnel or nuptial chamber below the entrance hole. Eggs are laid singly in niches on both sides of the gallery. The larvae feed away from the gallery, following the grain of the wood and deeply engraving it. Pupation occurs in deep pupal cells between the bark and the wood.

In Canada, there is one generation per year or possibly one and a partial second.

This species causes very little economic damage.



Map 37. Distribution of *Leperisinus aculeatus*.

Leperisinus fasciatus (LeConte)

Diagnosis. Length 2.0–2.5 mm. Frons flattened, with a sharply elevated longitudinal carina (♀) or deeply, ovally concave (♂), transversely impressed above epistoma, surface dull, reticulate, densely pubescent; pronotal asperities prominent, confined to lateral areas, not extending to median portion of anterior pronotal margin; suture 3 of antennal club weakly arcuate; pronotal surface dull, reticulate, bearing scattered granules; elytral interspaces finely rugose, median row of rugosities not evident; vestiture consisting of black and white to yellowish white scales, the contrast in color sharply defined.

Hosts. *Fraxinus* spp.

Distribution. Southern Ontario; eastern United States and probably into Mexico.

Biology. Not investigated.

Leperisinus criddlei Swaine

Diagnosis. Length 2.0–2.6 mm. Frons convex (♀) or flattened and longitudinally impressed (♂), transversely impressed above epistoma, surface dull, reticulate, with a faint longitudinal carina (♀ only), densely pubescent; pronotal asperities prominent, forming an arcuate line from the lateral area to the anterior pronotal margin, then to the opposite lateral area; suture 3 of antennal club transverse; pronotal surface reticulate, with fine scattered granules; elytral interspaces finely rugose, a median row of fine rugosities barely discernible; vestiture consisting of white to yellowish white and light to dark brown scales in a variable, variegated pattern.

Hosts. *Fraxinus* spp.

Distribution (Map 38). Eastern Canada, west to Saskatchewan; eastern United States, west to Colorado.

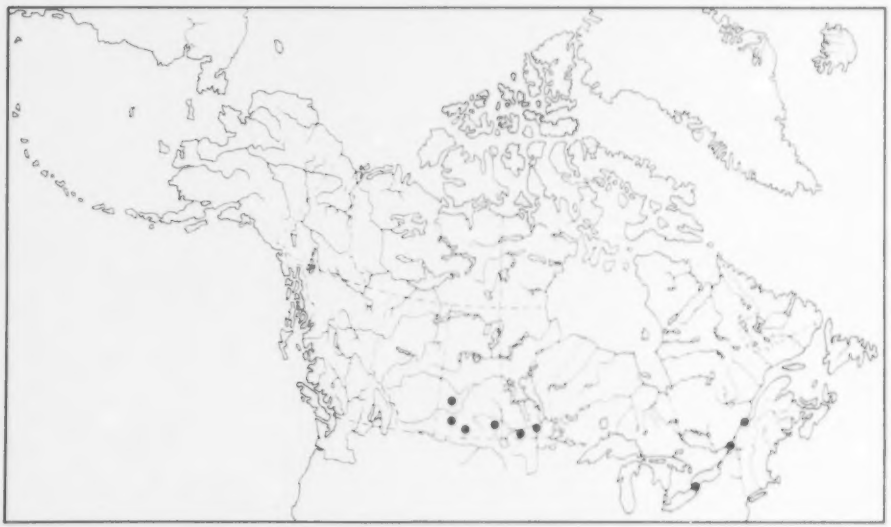
Biology. McKnight and Aarhus (1973).

In North Dakota, *L. criddlei* overwinters in hibernation chambers in the outer bark around the root collar of green ash trees 10–15 cm in diam. The overwintering adults emerge in mid-May and attack trees cut the preceding summer, trees girdled by rodents during the winter, or branches broken during winter or spring storms.

The egg galleries of *L. criddlei* are never stained black by the common *Ceratocystis* fungi. They are about 1 mm deep and 1 mm wide. No ventilation holes are visible. The egg galleries are often so close together on the bole of trees that the pupal chambers from different broods almost touch. The larval galleries, which are constructed above and below the egg gallery, are parallel and usually close together. In North Dakota, the adults emerge from July 25 to the end of August.

Leperisinus californicus Swaine (***californicus*** Essig, ***hoferi*** Blackman)

Diagnosis. Length 2.4–3.0 mm. Frons convex (♀) or concave (♂), more strongly, transversely impressed above epistoma, surface dull, punctate granulate, densely pubescent, with a strongly elevated, longitudinal carina (♀)



Map 38. Distribution of *Leperisinus criddlei*.

or a prominent, median, glabrous, smooth space (♂); pronotal asperities strongly developed except on median portion of anterior pronotal margin; suture 3 of antennal club obsolete, transverse; pronotal surface densely granulate; elytral interspaces rugose, with a median row of elevated rugosities; vestiture consisting of white and dark brown or dark reddish brown scales arranged in a variegated pattern, a median row of very large, spatulate scales is present on the declivital interspaces (except the second) of the male.

Hosts. *Fraxinus* spp.; *Olea* spp. in California.

Distribution. Southern Saskatchewan and southern Manitoba; western United States east to North Dakota and Texas.

Biology. Bright and Stark (1973) and McKnight and Aarhus (1973).

Adults emerge from their overwintering quarters in late May and early June and attack living trees, usually on twigs and branches, but sometimes on the bole. The transverse egg gallery in the cambium is typically forked, about 1.5 mm wide and about 1.5 mm deep. It is always darkly stained, apparently by *Ceratocystis* fungi. A row of ventilation holes about 1 mm in diam and about 4 mm apart directly over the egg gallery indicates an attack. Eventually the bark between the holes deteriorates and collapses, revealing the gallery beneath.

The egg gallery usually completely girdles small twigs and branches. As a result, the leaves on the girdled branches turn bright yellow; this "flagging" occurs in July and August in North Dakota.

The eggs are laid in niches along the gallery wall. On a typical branch several centimetres in diam, 6–12 larval mines extend upwards from the egg gallery and 2–3 mines turn downward. The larval mines are not parallel, they develop randomly and sometimes intercross. New adults start to emerge by early to mid-August. In North Dakota, the newly emerged adults constructed hibernation chambers soon after emergence, whereas in Oregon, egg galleries were constructed and the brood overwintered as second and third instar larvae.

This species does not usually cause economic damage. In 1969, severe branch killing, top killing, and sometimes tree mortality in green ash was observed in North Dakota. This species may be a problem in shelterbelt plantings and in urban and rural environments.

Genus *Phloeosinus* Chapuis

Members of *Phloeosinus* are easily recognized by the chunky body, the flattened, elongate antennal club, the unarmed pronotum, and the convex declivity that bears large teeth or granules on interspaces 1 and 3. The frons of the male is concave, whereas that of the female is convex.

The genus was revised by Blackman (1942).

Key to the species of *Phloeosinus* in Canada and Alaska

1. Mesosternum precipitous and protuberant between coxae; declivital interspace 2 granulate in both sexes (Fig. 14); in *Pinus* spp. and *Picea* spp. ..... ***pini*** **Swaine**

   Mesosternum flat, oblique or precipitous but not protuberant between coxae; declivital interspace 2 never granulate in either sex (except female *P. serratus*); in Cupressaceae 2

2. Declivital interspace 1 of male serrate throughout 3

   Declivital interspace 1 of male devoid of serrations or serrate only at top of declivity .. 9

3. Declivital interspace 2 of female with from one to many small, rounded granules (Fig. 15) (occasional specimens devoid of granules); declivital interspaces 1 and 3 of male with large, recurved serrations, these serrations smaller on third interspace (Fig. 16); body 2.3–3.7 mm long ..... ***serratus*** **LeConte**

   Declivital interspace 2 of female devoid of granules; declivital armature of male variable; size variable 4

4. Eastern species; vestiture on elytral interspaces abundant, hairlike; granules on declivital interspaces 1 and 3 minute on female or very small on male (Fig. 17) ..... ***canadensis*** **Swaine**

   Western species; vestiture on elytral interspaces abundant to sparse, hairlike to scalelike; granules on declivital interspaces 1 and 3 large in both sexes 5

5. Declivital interspace 2 on left elytron as wide as 1 or 3 (Fig. 18); declivital teeth of male rather sparse, flattened laterally (Fig. 18); declivital vestiture scalelike in female, more hairlike in male ..... ***scopulorum*** **Swaine**

   Declivital interspace 2 on left elytron narrower than 1 or 3; declivital teeth of male abundant, not flattened laterally; vestiture hairlike in both sexes 6

6. Elytral pubescence abundant on disk and declivity, disk with two or three ranks of setae on basal half 7

   Elytral disk glabrous or with a uniseriate row (rarely double) of hairlike setae; male declivity glabrous or with a few minute hairlike setae (Fig. 19); female declivity with hairlike and scalelike setae intermixed ..... ***punctatus*** **LeConte**

7. Male declivital tubercles small, sparse; frontal carina of male extending from epistomal margin about half the distance to center of excavation; body 2.3–2.5 mm long ..... ***keeni*** **Blackman**

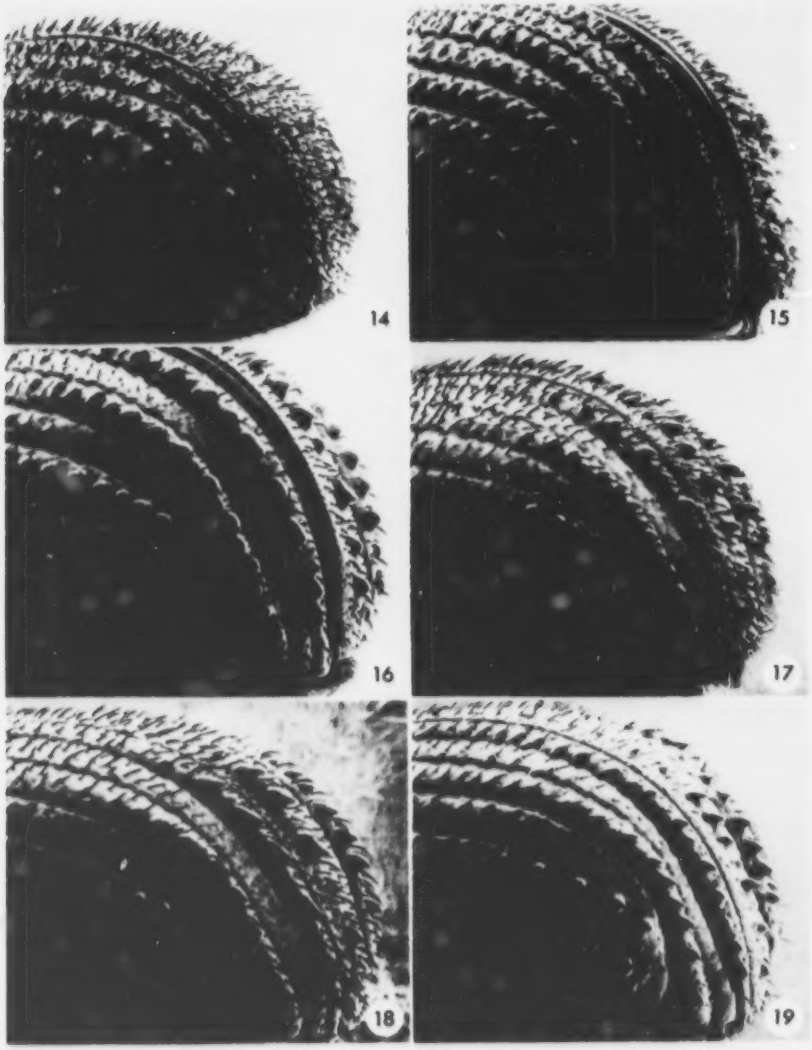
   Male declivital tubercles larger and more abundant; frontal carina of male well developed or absent; body 1.6–2.2 mm long 8

8. Frontal carina of male well developed, extending from epistomal margin to center of excavation; frons of female granulate-punctate throughout; declivital interspace 2 on left elytron much narrower than interspace 3 ..... ***hoppingi*** **Swaine**

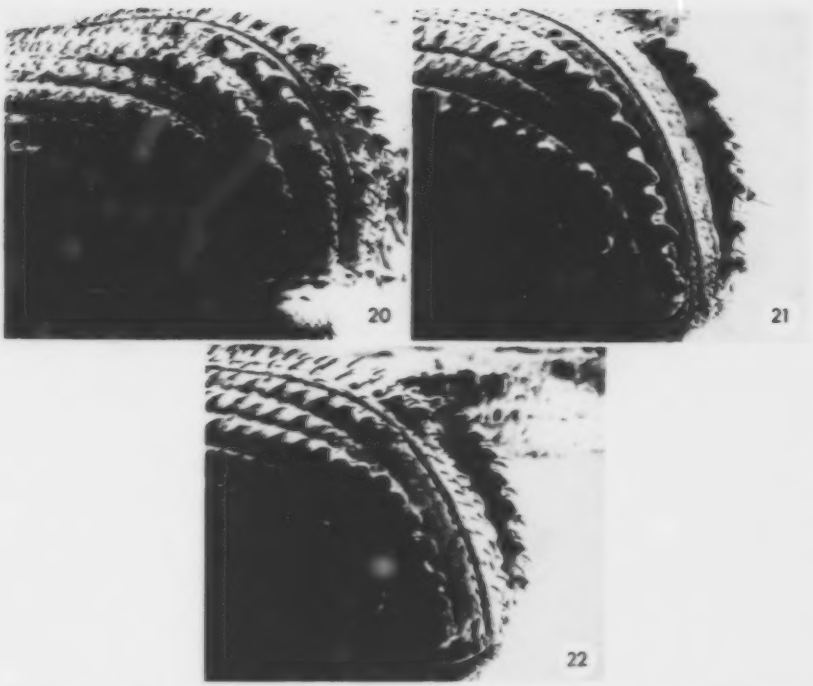
   Frontal carina of male absent, reduced to a tooth on epistomal margin; frons of female punctate above, feebly granulate on sides only; declivital interspace 2 on left elytron only slightly narrower than interspace 3 (Fig. 20) .... ***hoferi*** **Blackman**

9. Declivital interspace 1 of male devoid of serrations (Fig. 21); elytral striae narrow, with small indistinct punctures ..... ***sequoiae*** **Hopkins**

Declivital interspace 1 of male serrate only at top of declivity (Fig. 22); elytral striae wide with coarse punctures ..... ***cupressi*** **Hopkins**



Figs. 14–19. Declivities of *Phloeosinus* spp. 14, *P. pini*; 15, *P. serratus* ♀; 16, *P. serratus* ♂; 17, *P. canadensis* ♂; 18, *P. scopulorum* ♂; 19, *P. punctatus*.



Figs. 20–22. Declivities of *Phloeosinus* spp. 20, *P. hoferi*; 21, *P. sequoiae* ♂; 22, *P. cupressi* ♂.

Phloeosinus pini Swaine (***picese*** Swaine, ***alaskanus*** Blackman) (Fig. 14)

Diagnosis. Length 2.1–2.5 mm. Frons of both sexes strongly granulate, longitudinal carina short, rather faint; pronotum finely, densely punctured; elytral interspaces strongly rugose; declivital interspaces 1, 2, and 3 with minute granules (♀) or with somewhat larger granules (♂); vestiture abundant, hairlike on elytral disk, becoming more scalelike on declivity.

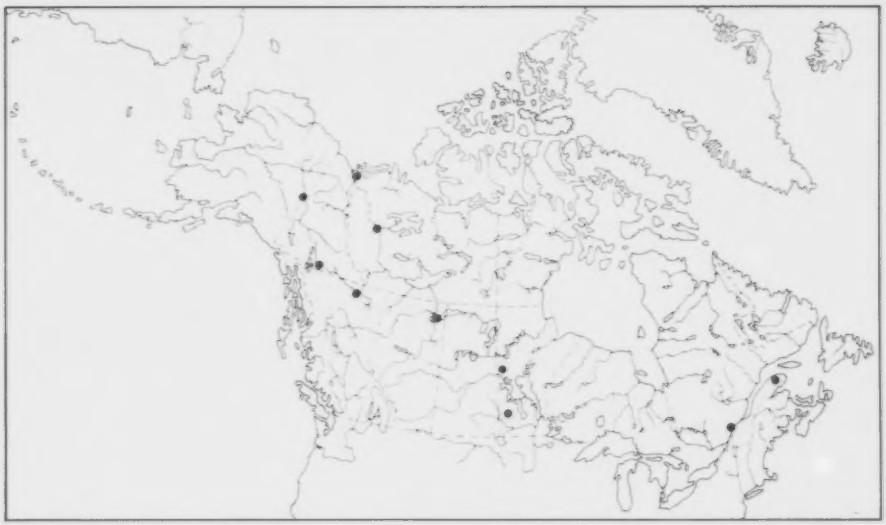
Hosts. *Pinus* spp. and *Picea* spp.

Distribution (Map 39). Transcontinental.

Biology. Not investigated.

Phloeosinus serratus LeConte (***utahensis*** Swaine, ***juniperi*** Swaine, ***aciculatus*** Bruck) (Figs. 15 and 16)

Diagnosis. Length 2.3–3.7 mm. Frons transversely concave or impressed (♂) to evenly convex (♀), rugose-granulate with a faint longitudinal carina (sometimes absent in ♀); pronotum closely, densely, deeply punctured;



Map 39. Distribution of *Phloeosinus pini*.

elytral interspaces rugose, granulate, and punctate; declivital interspaces 1, 2, and 3 with a median row of serrations or granules (♀); these smaller and sometimes absent on interspace 2, or declivital interspace 1 and 3 with a median row of coarse serrations, interspace 2 smooth (♂); vestiture abundant, scalelike (♀), or hairlike (♂).

Hosts. *Juniperus scopulorum*.

Distribution. Not recorded from Canada, but probably found in southern British Columbia; known from western United States (as far north as Washington) to southern Mexico.

Biology. Burke (1966).

Adults of *P. serratus* attack the main trunk and larger limbs of their host tree, and occasionally fresh juniper fence posts and poles. Weakened and dying trees are preferred, but occasionally large numbers of living trees have been killed.

Rather large egg galleries, 5–9 mm long, are excavated vertically in the phloem-cambial region both up and down the bole from a large chamber. Egg niches are closely spaced; up to 100 eggs per gallery have been recorded.

The larval mines engrave the sapwood and bark equally, but pupation usually occurs in the wood.

The life cycle and number of generations per year are not known.

Phloeosinus canadensis Swaine (Fig. 17)

Diagnosis. Length 2.0–2.8 mm. Frons transversely impressed to concave (♂) or convex to flattened (♀), finely granulate-punctate, with a fine, weakly elevated, longitudinal carina; pronotum deeply punctured; elytral interspaces coarsely granulate; declivital interspaces 1 and 3 of both sexes convex, serrate, the serrations larger on male; vestiture abundant, hairlike on disk and declivity.

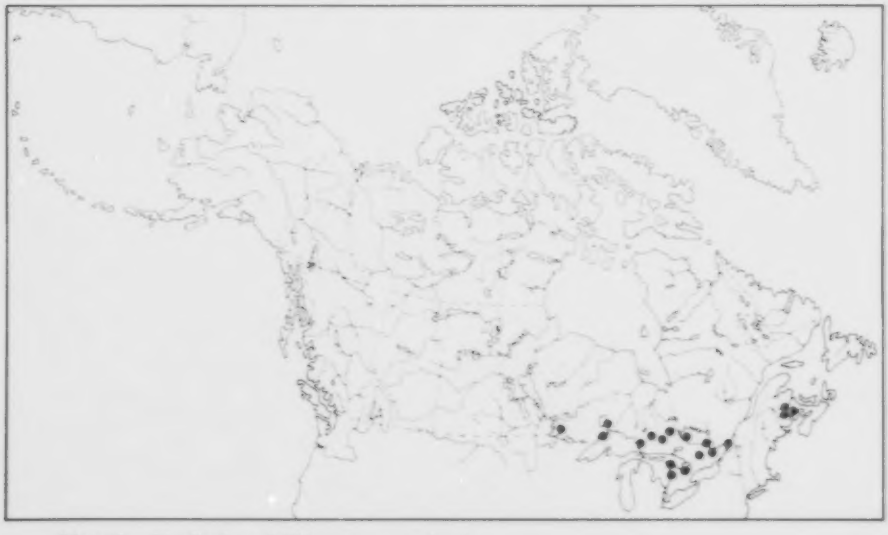
Hosts. Chiefly *Thuja occidentalis*; also *Juniperus virginiana*.

Distribution (Map 40). Eastern Canada; northeastern United States.

Biology. Chamberlin (1939).

Very little is known of the details of the life cycle and habits of this species. Only the gallery pattern is known.

Adults usually attack tops, limbs, and other weakened or injured parts of trees. The longitudinal gallery is 4–6 cm long, deeply engraving the wood. Eggs are placed singly in closely spaced, deep egg niches on both sides of the gallery. At the bottom or top of the egg gallery, an enlarged chamber or nuptial chamber is constructed. Larvae mine away from the gallery, across the grain; their mines are about 2.5 cm long. Pupal cells are constructed at the ends of the larval mines. The newly emerged adults feed for a short time in living twigs, killing the tips of the branches and producing a type of injury called flagging. There is one generation per year.



Map 40. Distribution of *Phloeosinus canadensis*.

Phloeosinus scopulorum Swaine (***neomexicanus*** Blackman is a subspecies) (Figs. 18 and 182)

Diagnosis. Length 2.4–3.7 mm. Frons transversely impressed, subconcave (♂) to convex (♀), surface granulate-punctate to punctate, with a distinct longitudinal carina (♂) or only an epistomal tooth (♀); pronotum closely, deeply punctured; elytral interspaces granulate; declivital interspaces 1 and 3 of both sexes serrate to granulate, the granules much larger in male; vestiture scalelike (♀) to hairlike (♂), abundant.

Host. *Juniperus scopulorum.*

Distribution (Map 41). Southern British Columbia; western United States.

Biology. Not investigated, but probably similar to *P. canadensis* (*see* the previous description).

Phloeosinus punctatus LeConte (***buckhorni*** Blackman, ***kaniksu*** Blackman, ***rustl*** Blackman, ***rubicundulus*** Swaine) (Figs. 19, 67, 113, and 151)

Diagnosis. Length 2.0–3.4 mm. Frons rather weakly concave (♂) or convex (♀), surface brightly shining, finely, densely granulate-punctate, with a distinct, elevated longitudinal carina; pronotum deeply, closely punctured; elytral interspaces brightly shining, rugose to granulate; declivital interspaces 1 and 3 of both sexes with median row of serrations (♂) or granules (♀); vestiture scalelike to hairlike, sparse to abundant, variable. A very variable species in regard to type and amount of pubescence, punctation, and in other characteristics.

Hosts. All species of Cupressaceae in its range.

Distribution (Map 42). Southern British Columbia; western United States.

Biology. Bright and Stark (1973).

Adults of *P. punctatus* attack the trunks and limbs (larger than 1 cm in diam) of apparently healthy, injured, dead, and recently felled host trees. Prematuration feeding on twigs is believed necessary for sexual maturation.

The wide variation in attack sites causes considerable variation in the pattern of the egg galleries. Most of the galleries are short (1–5 cm), run with the grain, and score the sapwood slightly. They may be straight or sinuous. However, deep engraving of the wood does occur. Another common pattern is biramous, with the two arms angled forming a V. Turning niches are formed at the base of the V, or in vertical single-armed galleries above the entrance hole.

Egg niches are widely spaced; the female lays about 12–40 eggs, the average is about 15 per gallery. Larval mines are irregular, running at all angles, depending on the size of material infested. In longitudinal galleries they are typical of the genus starting at right angles to the egg gallery, then turning up or down. However, they are usually winding and often intercross. The larvae feed chiefly in the inner bark.

Pupation occurs almost solely in the outer bark, particularly in biramous galleries. In longitudinal galleries pupation may occur in the sapwood. When this occurs, the pupal cell lies obliquely in the wood and is longer than the pupa and plugged with white frass.

There are three generations per year at lower elevations (below 1000 m). Adults are probably in flight throughout the warmer periods of the year.

P. punctatus is the most common species of *Phloeosinus* encountered in the forested regions of southern British Columbia. Damage is negligible, consisting of some twig-pruning during maturation feeding and occasionally the killing of small trees.

Phloeosinus keeni Blackman

Diagnosis. Length 2.3–2.5 mm. Frons shallowly concave (♂) or convex (♀), surface finely, closely granulate-punctate, with an indistinct, low, longitudinal carina; pronotum closely, deeply punctured; elytral interspaces closely punctate-granulate; declivital interspaces 1 and 3 convex, with a median row of small serrations, the serrations smaller in female; vestiture scalelike, abundant.

Hosts. *Chamaecyparis nootkatensis* and *Juniperus scopulorum*.

Distribution. Central British Columbia, probably also along the coast of British Columbia; Washington and Oregon.

Biology. Not investigated.

Phloeosinus hopkingi Swaine

Diagnosis. Length 1.6–2.0 mm. Frons deeply concave (♂) or convex, flattened (♀), surface densely granulate-punctate, with a distinctly elevated, longitudinal carina on lower half of frons of both sexes; pronotum very deeply, closely punctured; elytral interspaces closely granulate-punctate; declivital interspaces 1 and 3 of both sexes with serrations or granules, these large, acute, and close (♂), or low and round (♀); vestiture hairlike (♂) or scalelike (♀), abundant.

Host. *Juniperus scopulorum*.

Distribution. Southern British Columbia; Washington to California.

Biology. Bright and Stark (1973).

Very little of the biology is known. Attacks are limited to branches less than 5 cm in diam.

The egg galleries may be straight or winding, single or branched, and 1.5–4 cm long. The nuptial chamber is merely a widening of the gallery. Eggs are deposited in niches sealed with frass, and up to 15 eggs per cm have been recorded. After the eggs have been deposited, the adults often excavate feeding galleries. Pupation takes place mostly in the sapwood. The life cycle or number of generations per year are unknown.

Phloeosinus hoferi Blackman (Figs. 20 and 183)

Diagnosis. Length 1.6–2.2 mm. Frons deeply, broadly concave (♂) or convex (♀), surface closely granulate-punctate, with carina reduced to a blunt tooth on epistoma (♂) or definitely elevated on lower half of frons (♀); pronotum deeply, closely punctured; elytral interspaces confusedly granulate-punctate; declivital interspaces 1 and 3 of both sexes with serrations or granules, these stronger in male; vestiture hairlike (♂) or scalelike (♀), moderately abundant.

Host. *Juniperus scopulorum.*

Distribution (Map 41). Southern interior British Columbia; western United States.

Biology. Not investigated.

Phloeosinus sequoiae Hopkins (*squamosus* Blackman, *blackmani* Schedl) (Figs. 21 and 181)

Diagnosis. Length 3.2–4.2 mm. Frons rather deeply concave (♂) or convex, flattened (♀), surface densely rugose-granulate, with a weak median carina on lower half in both sexes; pronotum deeply, coarsely punctured; elytral interspaces strongly granulate-punctate and rugose; declivital interspace 1 devoid of serrations, 3 strongly serrate (♂), or interspaces 1 and 3 serrate or granulate, the granules smaller on first (♀); vestiture hairlike (♂) or scalelike (♀).

Host. *Thuja plicata.*

Distribution (Map 43). Southeast Alaska, western British Columbia; Washington to California.

Biology. Bright and Stark (1973).

Adults of *P. sequoiae* start flying as early as April in southern localities and they continue to be found throughout the warm weather. Flight peaks occur in early and late summer. Attacks are normally confined to injured or fallen

timber, but beyond its natural range attacks are common on weakened and dying trees. In fallen timber, attacks are usually confined to the sides and undersurface of the stem, but in standing trees any portion of the main trunk and limbs as small as 2 cm in diam may be attacked. The adults attack all sizes of trees. The twig-pruning habit common to many *Phloeosinus* species is not so pronounced in this species.

Females initiate the attack, excavate a nuptial chamber or turning niche 5 × 12 mm long, and tunnel upward parallel to the grain. The egg gallery may be straight or slightly winding, and near the distal end a short spur, probably used as a turning niche, is excavated. The length of the parent gallery varies up to 25 cm; the average is about 14 cm. Eggs are deposited in niches crowded closely together on both sides of the gallery. Reports on the numbers of eggs vary from a few to 200, but seldom over 150; the average is about 50 per gallery.

Larval galleries begin at right angles to the egg gallery but either turn upward or diverge to various degrees. Pupal cells are usually constructed in the sapwood, but in thick-barked areas they may be in the inner bark lightly scoring the sapwood.

There is one complete generation per year and a partial second. Broods overwinter mainly as mature larvae; often as young adults, parent adults, or immature larvae; and rarely as eggs or pupae. The overwintering parent adults extend their galleries and oviposit from March to May. The brood from these adults emerges in August or September. The overwintering teneral adults emerge in April or May and attack new hosts. The brood from these adults emerges slightly later than the brood from the parent adults. Overwintering mature larvae complete their development and adults emerge in June and July; the adults from the overwintering larvae may not emerge until August.

The second generation begins in September. The first adults to emerge from the first generation attack new host material and establish broods that give rise to the overwintering mature larvae, pupae, and sometimes teneral adults. The later emergents from the first generation give rise to overwintering parent adults, young larvae, and occasionally eggs.

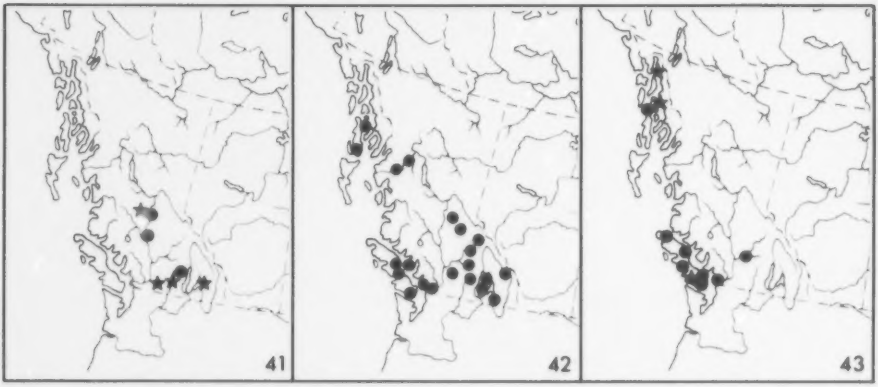
This species occasionally causes damage to ornamentals planted within its range.

Phloeosinus cupressi Hopkins (***nitidus*** Swaine) (Fig. 22)

Diagnosis. Length 2.0–3.6 mm. Frons broadly, moderately deeply concave (♂) or convex (♀), surface finely to roughly granulate-punctate, with median carina nearly entirely lacking (♂) or strongly elevated (♀); pronotum closely, very deeply punctured; elytral interspaces rugulose-granulate; declivital interspace 1 serrate only at top of declivity, interspace 3 with very coarse, dark, serrations (♂), or interspaces 1 and 3 with small or large serrations or granules, these smaller on first and extending to apex (♀); vestiture hairlike (♂) or scalelike (♀).

Hosts. *Thuja plicata* and *Chamaecyparis nootkatensis*.

Distribution (Map 43). Southeast Alaska, coastal British Columbia; Washington to California.



Maps 41–43. Distribution of *Phloeosinus* spp. 41, *P. scopulorum* (●) and *P. hoferi* (★); 42, *P. punctatus*; 43, *P. sequoiae* (●) and *P. cupressi* (★).

Biology. Bright and Stark (1973).

Adults usually enter the bark of dying or recently felled trees. In standing trees, any portion of the stem or branch system is attacked, but in fallen trees attacks are confined to the sides and shaded undersurface. Before entering the host, the adults attack small (less than 2 cm in diam) living twigs. They enter the twig and hollow out the center for a short distance. The twig usually breaks and may hang on the tree causing the flagging characteristic of twig-pruning. This is particularly noticeable from July through September.

The female enters the host first, soon followed by the male. A lopsided nuptial chamber is constructed at the base of the entrance tunnel. From this chamber a single, straight longitudinal tunnel 2–15 cm long (average, 7.5 cm) is excavated. This egg gallery is kept free of frass.

Up to 150 eggs are deposited in egg niches spaced evenly about 1 mm apart on both sides of the gallery. The larvae bore at right angles to the parent gallery but slowly diverge so that those farthest from the center are at an oblique angle. Larval gallery length seldom exceeds 10 cm. At the end of the gallery, the pupal cell is constructed; this cell engraves wood and bark about equally, but occasionally only the bark. The axis of the pupal cell may be in any direction.

There are probably two complete generations per year in Canada and Alaska. Occasionally, a third generation may be started within the year. The seasonal history follows. Overwintering young adults emerge, excavate galleries, and deposit eggs in April or May. The larvae hatch in late April and May and develop until July. The pupae and adults are found from May through July. This generation is normally completed by late July.

The second-generation adults fly and attack in late June, July, and early August. Eggs hatch quickly, development is rapid, and brood adults emerge in August and September. This generation is usually complete by early October. The adults from this generation may overwinter or, if the weather is favorable, they may attack new host material and begin a third generation.

Genus *Phloeotribus* Latreille

Members of *Phloeotribus* are easily recognized by the antennal club, which is deeply divided into three independently movable parts (Fig. 69), the entire eye, and the asperate pronotum.

Key to the species of *Phloeotribus* in Canada

1 Antennal club with laterally expanded segments more than twice as wide as their basal length (Fig. 69); elytral interspaces flat, smooth to sparsely, minutely granulate; in fruit trees ..... ***liminaris*** **(Harris)**

Antennal club with laterally expanded segments less than twice as wide as their basal length; elytral interspaces convex, strongly granulate to asperate; in coniferous trees 2

2 Western species; elytral surface dull, opaque, minutely reticulate ..... ***lecontei*** **Schedl**

Eastern species; elytral interspaces brightly shining ..... ***piceae*** **Swaine**

Phloeotribus liminaris (Harris) (Fig. 69)

Diagnosis. Length 1.8–2.5 mm. Frons strongly flattened to concave (♂) or only weakly flattened (♀), callus elevations usually present at level of antennal insertions in both sexes, surface opaque, reticulate; antennal club with segment 1 about 2.5 times wider than long; pronotum finely punctured; elytral interspaces shining, with a median row of fine granules; declivital interspaces narrower and more strongly granulate than on disk; vestiture consisting of a median row of long, hairlike setae in each interspace.

Hosts. Wild and cultivated stone-fruit trees.

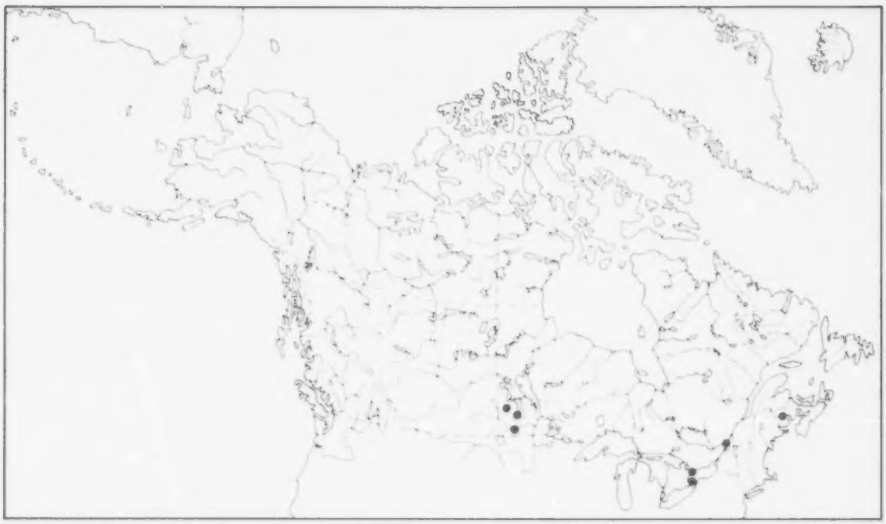
Distribution (Map 44). Southern Manitoba to New Brunswick; eastern United States.

Biology. Baker (1972).

This species, known as the peach bark beetle, is an occasional pest in peach orchards and at times may cause serious damage.

Breeding usually takes place in weakened trees, but the adults also feed in the bark of healthy trees. This bark feeding causes irritations, which may result in abnormal growth of the tree. Infested trees are not killed, but are seriously weakened and become susceptible to breeding attacks.

The winter is passed in the adult stage in hibernating burrows in the bark. The adults emerge in the spring, attack new host material, and lay eggs. The gallery is short, transverse, and usually consists of two short tunnels extending in either direction from the entrance hole and deeply engraving the wood. Larvae



Map 44. Distribution of *Phloeotribus liminaris*.

feed away from the egg gallery, with the grain of the wood. Pupation occurs in enlarged cells at the end of the larval mines.

There are two generations per year.

Phloeotribus lecontei Schedl (***puberulus*** LeConte, preoccupied)

Diagnosis. Length 2.3–2.8 mm. Frons deeply concave, with an acute tooth on lateral margins (♂) or convex, transversely impressed above epistoma (♀), surface dull, minutely reticulate or weakly granulate; antennal club with segment 1 from 1.6 to 1.7 times longer than wide; pronotum dull, with shallow punctures and scattered, small granules; elytral interspaces dull, with a median row of fine granules; declivital interspaces 3 and 9 joined and continuing to apex, granules larger in male; vestiture consisting of stout, flattened, interstrial scales and fine, hairlike, interstrial setae.

Hosts. Chiefly *Pseudotsuga menziesii;* also *Abies* spp.

Distribution (Map 45). Southern British Columbia; western United States.

Biology. Not investigated.

Map 45. Distribution of *Phloeotribus lecontei* (★) and *P. piceae* (●).

Phloeotribus piceae Swaine (Figs. 114 and 152)

Diagnosis. Length 1.8–2.1 mm. Frons concave, with an acute tooth on lateral margin (♂) or convex, transversely impressed above epistoma (♀), surface dull, minutely reticulate; antennal club with segment 1 from 1.6 to 1.7 times wider than long; pronotum shallowly punctured, dull; elytral interspaces shining, with a median row of fine granules; declivital interspaces 3 and 9 of both sexes serrate, joined near apex, and continuing to apex, granules larger in males; vestiture consisting of stout, flattened, interstrial scales and fine, hairlike, interstrial setae.

Hosts. *Picea* spp.

Distribution (Map 45). Manitoba to Quebec; northeastern United States.

Biology. Not investigated.

Genus *Chramesus* LeConte

Chramesus hicoriae LeConte (Figs. 70, 115, and 153)

Diagnosis. Length 1.5–1.8 mm. Frons deeply concave, lateral margins sharply elevated below eyes (♂) or convex, weakly transversely impressed above epistoma (♀), surface dull, reticulate-punctate; pronotal surface asperate,

asperities stronger on lateral areas; elytral interspaces dull, with a median row of small granules; declivity not modified; vestiture consisting of a row of erect, scalelike, interstrial setae and numerous, recumbent, interstrial, scalelike setae.

Hosts. *Carya* spp.

Distribution (Map 46). Ontario and Quebec; eastern United States.

Biology. Chamberlin (1939).

Little is known about this species except the gallery pattern. The entrance tunnel is usually started at the base of a twig or in some roughened spot. The egg gallery is simple, longitudinal, with a turning niche under the entrance hole. This gallery is about 2–4 cm long, deeply engraving the sapwood. From 15 to 60 eggs are placed singly in niches along the gallery wall. Larvae mine at right angles from the gallery but soon turn either up or down and run with the grain of the wood. Pupal cells are constructed either largely or entirely in the wood.

There is one generation per year in Canada. Adults of this species attack limbs, branches, or shoots that are injured or dying. This species is of no economic importance.

Genus *Chaetophloeus* LeConte

Chaetophloeus heterodoxus (Casey) (*brittaini* Swaine, *criddlei* Swaine) (Figs. 71, 117, and 154)

Diagnosis. Length 1.5–2.5 mm. Frons rather deeply, broadly concave, with an acute tubercle on each side of median line at upper part of impression (♂), or more weakly concave, tubercle absent (♀), surface dull, densely minutely granulate, vestiture abundant; pronotum with three groups of asperities on each side; declivity unmodified; vestiture consisting of a row of erect, scalelike interstrial setae and numerous, recumbent, scalelike setae.

Hosts. *Pyrus* spp., *Prunus* spp., and *Cercocarpus* spp.

Distribution (Map 46). Southern Manitoba to British Columbia; western United States.

Biology. Bright and Stark (1973).

The principal flight period is late June, although adults have been observed later in the summer. These adults may be from a second generation or from overlapping generations.

Both sexes apparently enter the host at the same time. The species is monogamous. The nuptial chamber is roughly oval, 4 × 6 mm, and engraves the

Map 46. Distribution of *Chramesus hicoriae* (★) and *Chaetophloeus heterodoxus* (●).

wood deeply. From 3 to 6 short galleries extend from this chamber, and 6–12 eggs are deposited at the end of each.

Larval galleries extend about 2 cm from the egg gallery, engraving the wood deeply. Oval pupal chambers are constructed at the end of the larval galleries, about three-quarters in the wood, one-quarter in the bark.

There is apparently only one generation per year in the northern part of its range. Adults have been observed ovipositing in July, and the parent adults as well as brood adults were still in the host a year later. However, since overwintering adults have been found to lay eggs the following spring, the possibility of a second, overlapping generation exists.

Genus *Carphoborus* Eichhoff

Members of *Carphoborus* can be distinguished by the five-segmented antennal funicle (Fig. 72), the flattened, oval to elongate antennal club bearing three distinct sutures (Fig. 72), the elevated basal margins of the elytra, and the dense, scaly pubescence. The genus was revised by Wood (1954*a*).

Key to the species of *Carphoborus* in Canada and Alaska (Modified from Wood (1954*a*))

1. Antennal club large, broad, less than 1.2 times longer than wide; female frons impunctate and glabrous on a large median area; transverse impression of male frons conspicuous and extensive, the median elevations large and prominent; in Douglas-fir (Fig. 23) ..... ***vandykei*** **Bruck**

Antennal club small, narrow, 1.3 or more times longer than wide (Fig. 72); female frons punctate or granulate over entire surface; male frons less strongly impressed below, the median elevation smaller, often absent 2

2. Declivital interspace 9 not elevated or serrate behind elytral base; declivital elevation ending at junction of interspaces 3 and 9 3

Declivital interspace 9 regularly serrate and usually elevated from declivital base to junction with interspace 3, the elevation usually continuing from this junction to interspace 1 5

3. Declivital interspace 3 very strongly, broadly elevated, the serrations small, confused, more abundant on sides of elevation than on its summit; Eastern Canada ..... ***dunni*** **Swaine**

Declivital interspace 3 less strongly elevated, the serrations larger, confined to summit; Western Canada and Alaska 4

4. Declivital interspace 1 strongly elevated, rather coarsely serrate; elevation of interspace 3 highest near middle of declivity; Alberta ..... ***sansoni*** **Swaine**

Declivital interspace 1 slightly elevated, finely serrate; elevation of declivital interspace 3 highest near apex (Fig. 24); Alberta, Northwest Territories, and Alaska ..... ***andersoni*** **Swaine**

5. Frons of female flattened, rather coarsely punctured; declivital teeth on interspace 3 very coarse, longer than height of interspace (Fig. 25) ..... ***ponderosae*** **Swaine**

Frons of female flattened or convex, more finely punctured; declivital teeth fine, those on interspace 3 much shorter than height of interspace 6

6. Discal striae about as wide as interspaces; declivital interspaces 4, 6, and 8 subtuberculate (Fig. 26); frons of female more coarsely punctured; frontal pubescence longer and more numerous ..... ***intermedius*** **Wood**

Discal striae much wider than interspaces; declivital interspaces 4, 6, and 8 not tuberculate (Fig. 27); frons of female finely punctured; frontal pubescence shorter ..... ***carri*** **Swaine**

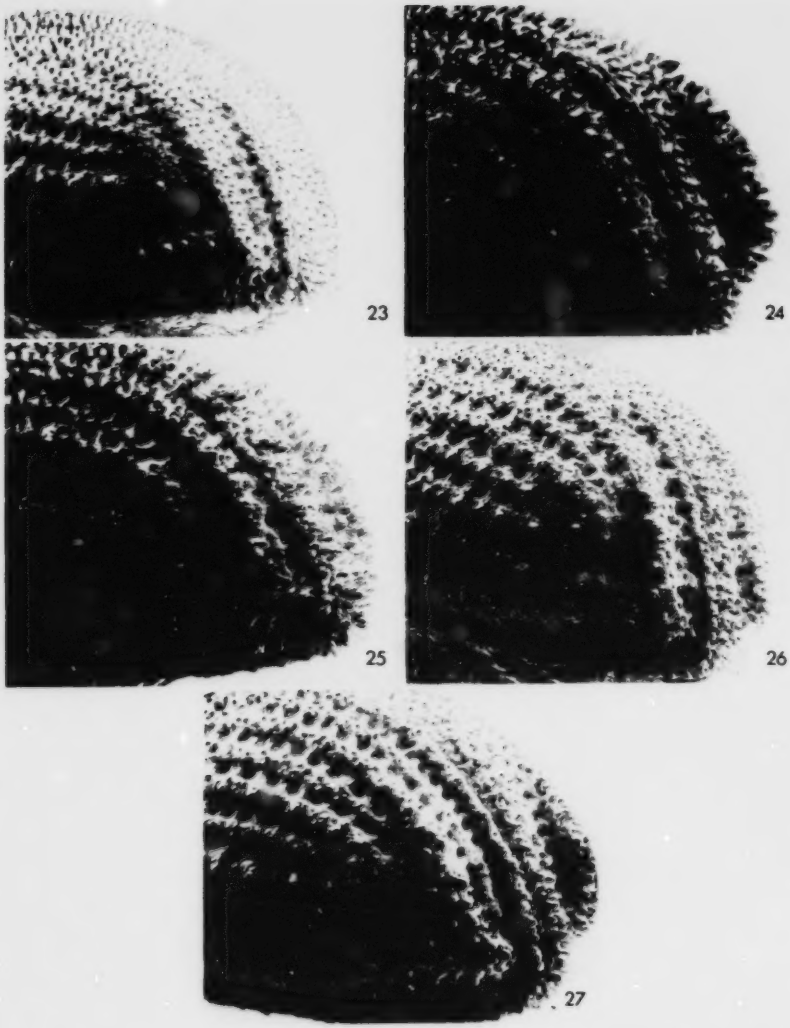
Carphoborus vandykei Bruck (Fig. 23)

Diagnosis. Length 1.8–2.6 mm. Frons flattened (♀) or transversely impressed with an evident median elevation (♂), surface glabrous in median area (♀) or coarsely punctured (♂); pronotum closely, deeply punctured; elytral interspaces coarsely, deeply, closely punctured; declivital interspaces 1 and 3 distinctly elevated, 1, 3, 5, 7, and 9 finely serrate; vestiture consisting of small, abundant, interstrial scales, these scales wider in male.

Host. *Pseudotsuga menziesii.*

Distribution. Southern British Columbia; Washington to central California.

Biology. Not investigated.



Figs. 23–27. Declivities of *Carphoborus* spp. 23, *C. vandykei*; 24, *C. andersoni*; 25, *C. ponderosae*; 26, *C. intermedius*; 27, *C. carri*.

Carphoborus dunni Swaine

Diagnosis. Length 1.6–1.9 mm. Frons convex (♀) or strongly convex, more deeply transversely impressed (♂), surface granulate, sparsely pubescent in both sexes; pronotum reticulate, closely, deeply punctured; elytral interspaces deeply, coarsely, randomly punctured; declivital interspace 3 strongly, broadly elevated, randomly serrate, interspaces 1, 5, and 7 weakly elevated, finely serrate; vestiture consisting of large, slender, abundant, semierect, interstrial scales.

Host. *Picea rubens*. .

Distribution. Known only from New Brunswick but probably occurs throughout Eastern Canada and the northeastern United States.

Biology. Not investigated.

Carphoborus sansoni Swaine (*engelmanni* Wood)

Diagnosis. Length 1.8–2.1 mm. Frons flattened, weakly impressed above epistoma (♀) or strongly convex, strongly impressed above epistoma (♂), surface coarsely punctured, vestiture long, coarse (♀); pronotum deeply, closely punctured; elytral interspaces deeply, coarsely, randomly punctured; declivital interspaces 1 and 3 moderately elevated, serrate, interspaces 5 and 7 serrate but not elevated; vestiture consisting of large, abundant, erect, interstrial scales.

Hosts. *Picea* spp.

Distribution (Map 47). Alberta; Utah and Wyoming.

Biology. Not investigated.

Carphoborus andersoni Swaine (Fig. 24)

This species is closely related to *C. sansoni* (see the previous description), and, in fact, may be a northern subspecies. It differs from *C. sansoni* by the less strongly elevated, more finely serrate declivital interspace 1 and the more strongly elevated declivital interspace 3.

Host. *Picea glauca*.

Distribution (Map 47). Northern Alberta and Northwest Territories to Alaska.

Biology. Not investigated.

Carphoborus ponderosae Swaine (Figs. 25 and 72)

Diagnosis. Length 1.8–2.1 mm. Frons flattened (♀) or transversely concave with the median elevation above the impression absent (♂), surface coarsely punctured, vestiture long (♀); pronotum coarsely, deeply punctured; elytral interspaces coarsely, deeply, randomly punctured; declivital interspaces 1, 3, and 9 strongly elevated, very coarsely serrate, interspaces 3 and 9 joined and continuing to 1; vestiture consisting of small, abundant, erect, interstrial setae.

Hosts. *Pinus ponderosa* and *P. contorta.*

Distribution (Map 48). Southern British Columbia; western United States.

Biology. Not investigated.

Carphoborus intermedius Wood (Fig. 26)

Diagnosis. Length 1.9–2.1 mm. Frons flat, shining (♀) or convex, transversely impressed, with median elevation absent (♂), surface coarsely, shallowly punctured, vestiture very long, fine (♀); pronotum very closely, deeply punctured; elytral interspaces deeply, coarsely, randomly punctured; declivital interspaces 1 and 3 elevated; 1, 3, and alternate interspaces finely serrate; vestiture consisting of abundant, semierect, interstrial scales.

Hosts. *Picea engelmannii* and *Pinus contorta.*

Distribution. Southern British Columbia; Washington to California and Colorado.

Biology. Not investigated.

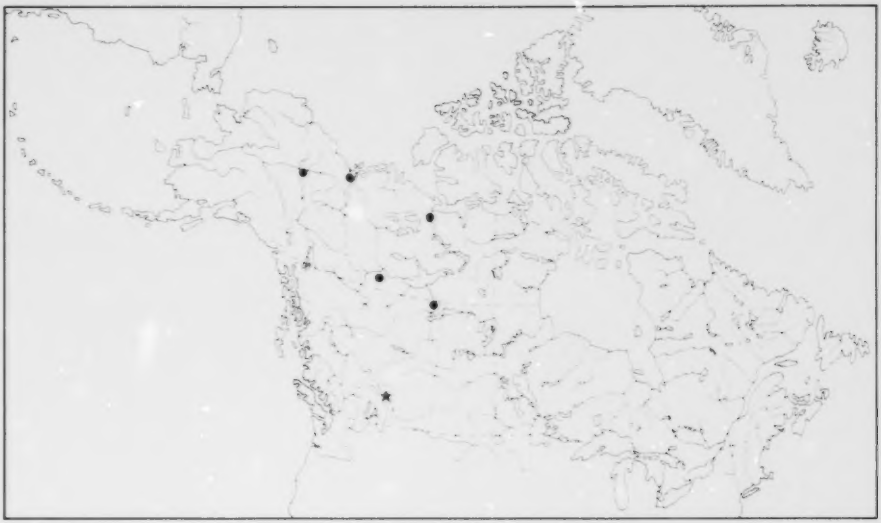
Carphoborus carri Swaine (Figs. 27, 116, and 155)

Diagnosis. Length 1.4–2.0 mm. Frons flattened in both sexes, more deeply impressed above epistoma in male, surface shining, coarsely to finely, deeply punctured, vestiture long (♀); pronotum closely, coarsely punctured; elytral interstriae coarsely, deeply punctured; declivital interspaces 1 and 3 elevated, interspace 3 more elevated; 1, 3, and alternate interspaces finely serrate, 3 and 9 joined and sometimes continuing to 1; vestiture consisting of large, abundant, semierect, interstrial scales, many appearing multilamellate.

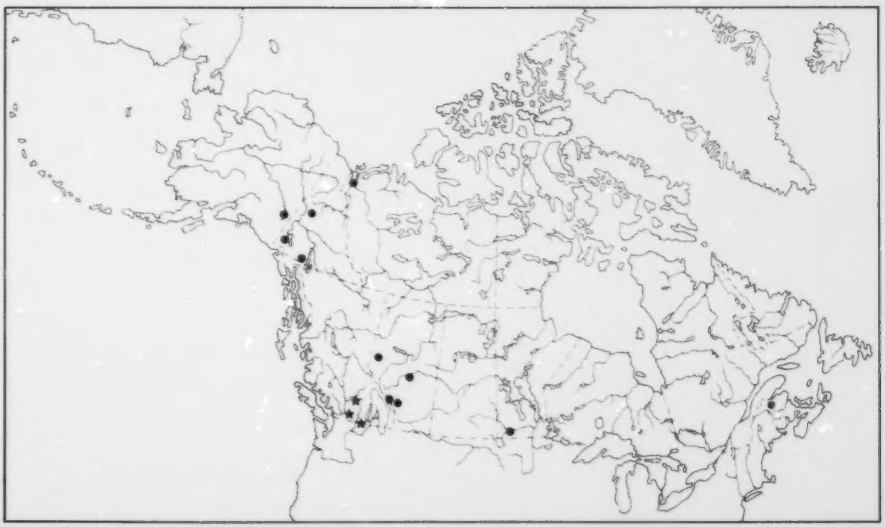
Hosts. *Picea* spp.

Distribution (Map 48). Transcontinental in Canada; South Dakota.

Biology. Not investigated.



Map 47. Distribution of *Carphoborus sansoni* (★) and *C. andersoni* (●).



Map 48. Distribution of *Carphoborus ponderosae* (★) and *C. carri* (●).

Genus *Polygraphus* Erichson

Members of this genus are very easily recognizable by the solid, unsegmented antennal club (Fig. 73), the completely divided eye, the evenly convex declivity, and the dense scaly pubescence.

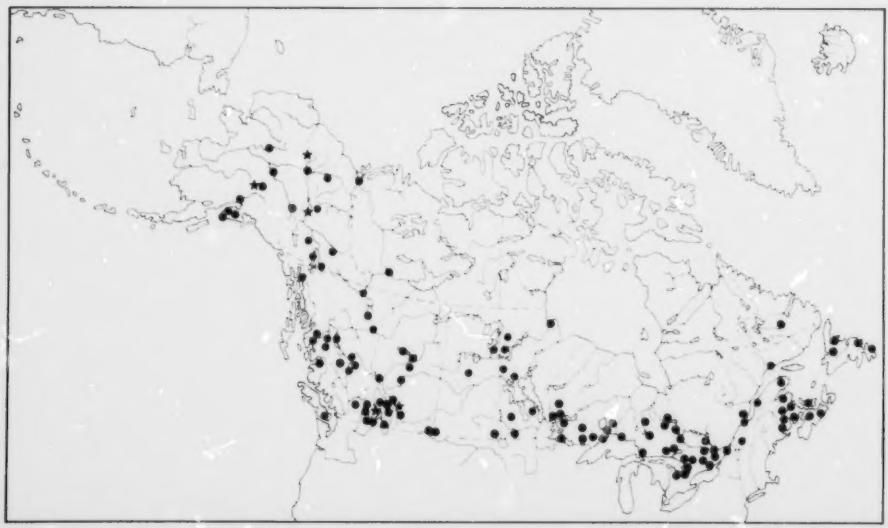
Key to the species of *Polygraphus* in Canada and Alaska

1. Tip of antennal club distinctly extended, acuminate; female frons convex, devoid of long pubescence; Western Canada and Alaska, at high elevations . . ***convexifrons*** **Wood**

   Tip of antennal club narrowly rounded, not acuminate or extended (Fig. 73); female frons flat to weakly concave, bearing long pubescence; generally distributed in coniferous forest regions of Canada and Alaska . . . . . ***rufipennis*** **(Kirby)**

Polygraphus convexifrons Wood

Diagnosis. Length 2.5–3.2 mm. Frons convex, with short, yellowish pubescence (♀) or concave to flat, with frontal tubercles (♂), surface finely punctured; antennal club acuminate at tip; elytra and pronotum clothed with dense whitish scales; declivital interspaces 1 and 3 slightly elevated, and interspace 3 smooth or with median row of small granules, surface densely punctured.



Map 49. Distribution of *Polygraphus rufipennis* (●) and *P. convexifrons* (★).

Hosts. *Pseudotsuga menziesii*, *Pinus contorta*, and *Picea* spp.

Distribution (Map 49). Central Alaska to Yukon Territory; Colorado and Utah.

Biology. Not investigated.

Polygraphus rufipennis (Kirby) (***brevicornis*** Kirby, ***nigriceps*** Kirby, ***saginatus*** Mannerheim) (Figs. 73, 118, 156, and 180)

Diagnosis. Length 2.1–3.1 mm. Frons flat to concave, with long pubescence (♀) or concave below frontal tubercles (♂), surface finely punctured; antennal club narrowly rounded at tip; elytra and pronotum clothed with white or yellowish scales; declivity as in *P. convexifrons* (see the previous description).

Hosts. All conifers in its range.

Distribution (Map 49). Transcontinental in Canada; eastern United States south to North Carolina and Tennessee, western United States south to Oregon and New Mexico.

Biology. Hinton (1968).

In Alberta, adults that have overwintered emerge in late May or early June and fly in search of new host material, usually dead or dying spruce. In Ontario, adults start their flight activity in late April. If the beetles have overwintered as larvae or pupae, they complete their development in the spring and emerge in late June or July.

The female excavates the entrance hole and, when she reaches the cambial layer, constructs the nuptial chamber. At about this time, she is joined by the male and mating takes place. From one to three more females enter the nuptial chamber, mate, and construct egg galleries. Each female positions her egg gallery as far as possible from the others. The entire gallery system can therefore be uniramous to radiate or star-shaped (Fig. 180). Eggs are laid in niches cut into the gallery wall. No particular pattern is followed in the placement of egg niches. The larvae burrow at right angles to the egg tunnels, continuing in this direction unless they run into an obstacle. Pupal cells are constructed at the ends of the larval mines.

In Alberta, there is one generation per year or one and part of a second, with two broods per season. In northern areas such as the Yukon Territory, there may be only one brood, but as many as three may be found farther south.

Genus *Pseudothysanoes* Blackman

Pseudothysanoes rigidus (LeConte) (***drakei*** Blackman) (Fig. 75)

Diagnosis. Length 1.5 mm. Frons strongly concave (♀) to weakly concave or flattened (♂); antennal club rather large, suture 1 broadly curved, suture 2 angulate; anterior margin of pronotum with four or five small, sharp

serrations, summit of pronotum reddish; elytral declivity with fine, short, strial setae and longer, coarser, clavate interstrial bristles.

Host. *Tilia americana.*

Distribution. Southeastern Canada; eastern United States.

Biology. Chamberlin (1939).

The galleries of this species lie entirely in the outer part of the porous inner bark and apparently never upon the surface of the sapwood. From the entrance gallery, a short branch extends longitudinally in opposite directions about 8 mm long. This is apparently used as a nuptial chamber and a turning niche. From the end of each of these branches an egg gallery extends transversely on each side. Egg niches are found only in these transverse galleries. The larvae bore into the bark in a longitudinal direction.

The beetles are normally polygamous. Each female is responsible for one arm of the transverse galleries.

Genus *Thysanoes* LeConte

Thysanoes fimbricornis LeConte

Diagnosis. Length 1.5–1.9 mm. Frons strongly concave (♀) to weakly concave or flattened (♂), surface smooth, shining above epistoma; antennal club elongate-oval, sutures arcuate; antennal scape club-shaped, pubescent, more accentuated in female; pronotum rather strongly asperate on anterior portion; elytral interspaces each bearing a uniseriate row of broad, flattened setae; elytral declivity evenly convex, setae broader and slightly longer.

Hosts. *Carya* spp., *Quercus* spp., and probably other genera of broadleaf trees.

Distribution. Not recorded from Canada, but probably found in southern Ontario; recorded from the eastern United States and Mexico.

Biology. Chamberlin (1939).

Galleries of this species are found in small branches or twigs. Three or four egg galleries, each about 2.5 cm long, are constructed just within the sapwood or in the cambium, radiating from the nuptial chamber. Occasionally a second set of egg galleries will be constructed from the same nuptial chamber; these galleries extend deeper in the sapwood and are shorter than the outer set. The eggs are laid in deep niches. When the larvae emerge, they mine entirely in the wood. Nothing concerning the seasonal history has been recorded in the literature.

Genus *Hylocurus* Eichhoff

Members of this genus are recognizable by the club-shaped antennal scape that bears only a few setae, the broadly procurved sutures of the antennal club, the slender fore tibia that is slightly wider at the apex and bears tubercles on the posterior face, and the other characters presented in the key to the genera. A key to the species in this genus was prepared by Blackman (1928*a*).

Key to the species of *Hylocurus* in Canada

1. Frons deeply concave; eastern species 2

   Frons convex; western species ..... ***hirtellus*** **(LeConte)**

2. Spongy areas of concave portion of frons small, hemispherical, arising from the lateral areas of the concavity; antennal club oval; declivital striae 1 and interspace 1 on female bearing a slight elevation ..... ***rudis*** **(LeConte)**

   Spongy areas of concave portion of frons large, flat, arising from bottom of concavity; antennal club nearly circular; declivital striae 1 and interspace 1 of both sexes flat, not bearing an elevation ..... ***biorbis*** **(Blackman)**

Hylocurus hirtellus (LeConte) (***crinitus*** Blackman)

Diagnosis. Length 2.4–3.0 mm. Frons convex to flattened in both sexes, bearing a small, circular brush of closely placed, yellowish setae (♀) or vestiture sparse, evenly scattered (♂), surface punctate-granulate; antennal club oval, sutures weakly arcuate; pronotum broadly rounded anteriorly, anterior slope with numerous, scattered asperities, posterior surface with a circular depressed area on each side of median line, these areas bearing longer, more erect, more abundant setae; elytral strial punctures rather large; elytral interspaces convex with a median row of small, rounded granules; elytral declivity convex, interspaces more strongly granulate than on disk.

Hosts. *Alnus* spp. and *Salix* spp.; also other genera of broadleaf trees and shrubs.

Distribution. Not recorded from Canada, but probably occurs in southern British Columbia, especially Vancouver Island; Washington to Baja California.

Biology. Bright and Stark (1973).

No detailed biological studies have been made. However, it is known that adults attack the stem or twigs of their host plants and bore into the wood. Distinct vertical galleries are constructed and packed with dry powderlike frass. Egg niches are widely spaced. Larvae mine in the wood with the grain. Several generations may develop in the same stem, and several generations may be produced each year.

Hylocurus rudis (LeConte)

Diagnosis. Length 2.0–2.3 mm. Frons deeply concave, with a circular spongy area on each side, each area rather small, hemispherical, and arising on the inner lateral margins of the concavity, otherwise surface smooth, shining; antennal club oval, sutures bisinuate; antennal scape small, club-shaped; pronotum broadly rounded anteriorly, anterior slope bearing numerous, close-set, low asperities, posterior surface bearing more widely spaced, flat asperities; elytral strial punctures large; elytral interspaces smooth and convex on disk; elytral declivity steep, interspaces granulate, more strongly granulate on interspaces 3 and 9, interspace 1 and striae 1 (♀) bearing a slight elevation, elytral apex strongly acuminate.

Hosts. *Carya* spp., *Castanea dentata*, *Acer* spp., and probably other genera of broadleaf trees.

Distribution. Not recorded from Canada, but probably found in southern Ontario; known from the eastern United States north to Detroit, Michigan.

Biology. Chamberlin (1939).

This species attacks small limbs and shoots, preferably those that have died recently.

Hylocurus biorbis (Blackman)

Diagnosis. Length 2.0–2.2 mm. Very similar to *H. rudis* described above except that the spongy areas on the frons are larger and arise from the bottom of the concavity, the antennal club is circular and the declivital interspace 1 and striae 1 are flat in both sexes. This may be a variety of *H. rudis*, or the names may be synonymous.

Hosts. *Carya* spp.

Distribution. Not recorded from Canada, but probably found in southern Ontario; known from the eastern United States north to Syracuse, New York.

Biology. Not investigated.

Genus *Micracis* LeConte

Members of *Micracis* are readily recognizable by the elongate body, the acuminate sutural apex of the elytra, the greatly enlarged, flattened, densely pubescent antennal scape of the female (Fig. 74), and the characters given in the key to the genera.

A key to the species in this genus was prepared by Blackman (1928*a*).

Key to the species of *Micracis* in Canada

1. Length (♀) less than 2.4 mm; declivital interspace 3 not elevated; elytral pubescence of both sexes hairlike ..... ***swainei*** **Blackman**

   Length (♀) 2.5–2.9 mm; declivital interspace 3 weakly elevated; elytral pubescence of female hairlike, that of male scalelike ..... ***suturalis*** **LeConte**

Micracis swainei Blackman (***populi*** Swaine) (Figs. 58, 74, 119, and 157)

Diagnosis. Length 1.9–2.3 mm. Frons flattened, somewhat flatter just above epistoma, finely pubescent except for a dense brush on median portion of epistoma (♀) or more convex, with dense scalelike setae over surface, epistomal brush absent (♂); antennal funicle strongly expanded laterally, densely pubescent with long setae (♀) or much smaller, triangular, not densely pubescent (♂); elytral interstriae narrow, with a median row of very fine granules; declivity convex, interstrial granules larger than on disk; vestiture of both sexes hairlike on elytra.

Hosts. *Salix* spp. and *Populus* spp.

Distribution. Southern Ontario; eastern United States.

Biology. Not investigated. Specimens have been collected from galleries situated in the wood just beneath the bark of a broken limb. Larvae are believed to feed in the wood.

Micracis suturalis LeConte (***aculeatus*** LeConte, ***meridianus*** Blackman)

Diagnosis. Length 2.5–2.9 mm. Frons strongly flattened to concave with epistomal margin elevated in both sexes, sparsely pubescent, finely reticulate (♀) or densely pubescent, strongly granulate-reticulate (♂); antennal funicle broadly triangular, densely pubescent with long setae (♀) or much smaller, triangular, not densely pubescent (♂); elytral interstriae broader, reticulate, not granulate; declivital interspace 3 weakly elevated, all declivital interspaces granulate; elytral vestiture hairlike (♀) or scalelike (♂).

Hosts. *Cercis canadensis*, *Juglans* spp., and other deciduous trees.

Distribution. Not known from Canada, but probably occurs in southern Ontario; eastern United States as far north as Michigan.

Biology. Chamberlin (1939).

This species is abundant in red bud and hickory limbs. Details of its biology are lacking, but it is reported in the literature as preferring old wood and that adults may emerge and reattack the same material for several generations. The galleries are long, longitudinal, and slightly undulating.

Genus *Micracisella* Blackman

Micracisella opacicollis (LeConte)

Diagnosis. Length 1.7–2.1 mm. Frons convex, flattened, or slightly concave above epistoma, surface strongly granulate (♂) to finely granulate (♀); antennal funicle enlarged, flattened, densely (♀) to sparsely (♂) pubescent; elytral declivity convex, interspaces finely rugose to subgranulate; vestiture on elytra and pronotum consisting of short, broad scales, these larger on declivity.

Hosts. Various broadleaf trees.

Distribution. Not recorded from Canada, but probably occurs in southern Ontario; eastern United States.

Biology. Not investigated.

Genus *Trypophloeus* Fairmaire

Members of *Trypophloeus* are distinguishable by the absence of a distinctly raised lateral line on the pronotum, the five-segmented antennal funicle (Fig. 76), the slender, pointed antennal club with three transverse sutures (Fig. 76), and the additional characters given in the key.

The genus was revised by Wood (1954*b*) under the name *Cryphalus* Erichson.

Key to the species of *Trypophloeus* in Canada (Modified from Wood (1954*b*))

1. Strial punctures impressed, at least on basal one-quarter of elytra; vestiture hairlike at least on anterior half of elytra; declivital bristles distinctly longer than half the distance between rows of bristles 2

   Strial punctures obscure on elytra; vestiture scalelike on at least posterior three-quarters of elytra; declivital bristles not longer than half the distance between rows of bristles 3

2. Strial punctures coarse, deep, at least on basal half of elytra; punctures on posterolateral areas of pronotum fairly large, deep, and close; scalelike pubescence confined to declivity ..... ***striatulus*** **(Mannerheim)**

   Strial punctures greatly reduced except on basal one-quarter of elytra; punctures on posterolateral areas of pronotum fairly small, shallow, scalelike pubescence covering posterior half of elytra ..... ***salicis*** **Hopkins**

3 Posterior extremity of interspace 4 either smooth or with minute rounded granules; the short, abundant elytral scales broad, rounded distally; frons usually not subconcavely impressed ..... ***populi*** **Hopkins**

Posterior extremity of interspace 4 with a row of one to five small, slender teeth, each at least twice as long as its basal width; the short, abundant elytral scales acuminate; frons usually subconcavely impressed ..... ***thatcheri*** **(Wood)**

Trypophloeus striatulus (Mannerheim) (***punctipennis*** Hopkins, ***nitidus*** Swaine) (Figs. 76, 120, and 158)

Diagnosis. Length 1.6–2.0 mm. Frons convex, with a Y-shaped impression beginning at upper level of eyes, surface coarsely reticulate above eyes and closely punctured below; pronotum with 4–8 contiguous or nearly contiguous teeth on anterior margin, punctures on posterior area quite deep; elytra shining, striae not impressed, punctures impressed on basal one-quarter; declivity convex, steep, interspaces each with a row of small, widely spaced granules.

Hosts. *Alnus* spp. and *Salix* spp.

Distribution (Map 50). Transcontinental in Canada; Idaho, Utah, and Minnesota.

Biology. Not investigated.

Trypophloeus salicis Hopkins (***concentralis*** Hopkins)

Diagnosis. Length 1.5–1.7 mm. Frons flattened, sometimes subconcave, weakly impressed above epistoma, surface weakly punctured; pronotum with 6 subcontiguous teeth on anterior margin, punctures on posterior area shallow; elytra shining, striae not impressed, punctures impressed on basal one-quarter, declivity steep, broadly impressed between interspaces 1 and 4, interspaces each with a row of fine granules, those on interspace 4 larger.

Hosts. *Alnus* spp. and *Salix* spp.

Distribution. Not recorded from Canada, but probably occurs on Vancouver Island and the mainland coast; known from Puget Sound, Washington, to central California.

Biology. Not investigated.

Trypophloeus populi Hopkins

Diagnosis. Length 1.7–2.1 mm. Frons flattened or weakly convex, weakly impressed above epistoma, surface coarsely reticulate above eyes, deeply punctured below; pronotum with four large, subcontiguous teeth on anterior margin, punctures on posterior area quite deep; elytra shining, striae not

impressed, punctures obscure; declivity convex, steep, slightly impressed between interspaces 1 and 4, interspaces each with a row of fine granules.

Hosts. *Populus* spp.

Distribution (Map 50). Probably transcontinental in Canada; Arizona, Colorado, Nevada, and Utah.

Biology. Not investigated.

Trypophloeus thatcheri (Wood)

Diagnosis. Length 1.5–1.9 mm. Frons flattened, usually subconcave, surface punctured and usually longitudinally subaciculate; pronotum with four large, subcontiguous teeth on anterior margin, punctures on posterior area rather deep; elytra shining, striae not impressed, punctures obscure; declivity convex, steep, with an indistinct impression between interspaces 1 and 4, interspaces each with a row of small granules, those on apex of interspace 4 much larger, slender, acute.

Host. *Populus tremuloides*.

Distribution (Map 50). Southern British Columbia; western United States.

Biology. Not investigated.

Map 50. Distribution of *Trypophloeus striatulus* (★), *T. populi* (●), and *T. thatcheri* (◎).

Genus *Procryphalus* Hopkins

Members of *Procryphalus* are recognizable by the absence of a distinct raised line on the basal and lateral margins of the pronotum, the presence of a complete septum in the first suture of the antennal club, the 4-segmented antennal funicle, and the only slightly ascending posterior margins of the elytra.

This genus was revised by Wood (1954*b*).

Key to the species of *Procryphalus* in Canada

1. Body less than 1.7 mm long; frons sparsely, shallowly punctured; elytral interspaces finely punctured on posterior three-quarters of disk; in *Salix* spp. . . ***utahensis*** **Hopkins**

Body longer than 1.8 mm; frons coarsely, deeply punctured; elytral interspaces coarsely granulate-punctate over entire surface; in *Populus tremuloides* . . ***mucronatus*** **(LeConte)**

Procryphalus utahensis Hopkins (***sallcis*** Hopkins) (Figs. 77, 121, and 159)

Diagnosis. Length 1.5–1.7 mm. Frons convex, shallowly punctured, transversely impressed above epistoma with an indistinct median ridge extending from upper level of eyes to epistoma; pronotum with quite long, hairlike setae on asperate portion, and short, narrow scalelike setae on posterior and lateral areas, anterior margin with eight teeth; declivity steep, convex, strial punctures smaller and shallower than on disk; elytral vestiture consisting of abundant, short, interstrial scalelike setae and longer, sparse, uniserial rows of scalelike bristles.

Hosts. *Salix* spp.

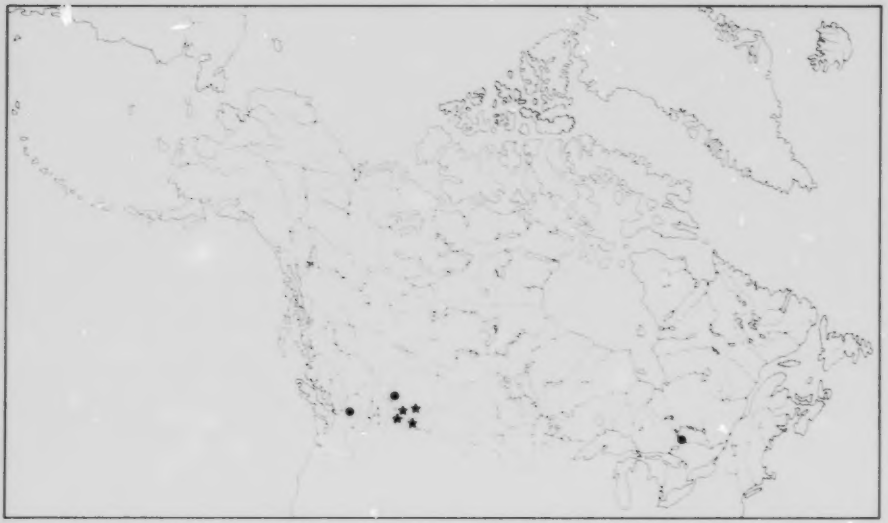
Distribution (Map 51). Probably transcontinental in Canada, but recorded only from British Columbia, Alberta, and Quebec; western United States.

Biology. Not investigated.

Procryphalus mucronatus (LeConte) (***idahoensis*** Hopkins, ***populi*** Hopkins)

Diagnosis. Length 1.8–2.2 mm. Frons convex, somewhat coarsely, deeply punctured, transversely impressed above epistoma with an indistinct ridge extending from upper level of eyes to epistomal margin; pronotum with moderately long, hairlike setae on asperate portion, and short, narrow, scalelike setae on granulate-punctate area, anterior margin with six teeth; declivity steep, convex, strial punctures smaller and shallower than on disk; elytral vestiture as in *P. utahensis*.

Host. *Populus tremuloides*.



Map 51. Distribution of *Procryphalus utahensis* (●) and *P. mucronatus* (★).

Distribution (Map 51). Western Canada; Colorado, Idaho, Nevada, and Utah.

Biology. Not investigated.

Genus *Cryphalus* Erichson

Members of this genus are recognized by the four-segmented antennal funicle, the large antennal club with three recurved sutures (Fig. 78), the emarginate eye, the pronotal summit that is on the basal one-third of the pronotum, and the broad and emarginate third tarsal segment.

Key to the species of *Cryphalus* in Canada

1. Elytral declivity with widely spaced, uniserial rows of interstrial, hairlike setae, each setae at least half as long as distance between rows ..... ***pubescens*** **Hopkins**

Elytral declivity without uniserial rows of long, interstrial, hairlike setae.....
..... ***ruficollis*** **Hopkins**

Cryphalus pubescens Hopkins (*subconcentralis* Hopkins)

Diagnosis. Length 1.6–1.9 mm. Frons weakly convex, with a short, often indistinct, longitudinal elevation above epistoma, surface coarsely, closely

punctured; elytral striae not impressed, punctures fine and shallow; elytral declivity steep, striae more obscure than on disk; elytral vestiture consisting of abundant, randomly placed, interstrial, scalelike setae and uniserial rows of very long, slender, interstrial, hairlike setae.

Hosts. *Abies* spp., *Pseudotsuga menziesii*, and *Picea* spp.

Distribution (Map 52). Coastal regions of British Columbia; coastal United States from Washington to California.

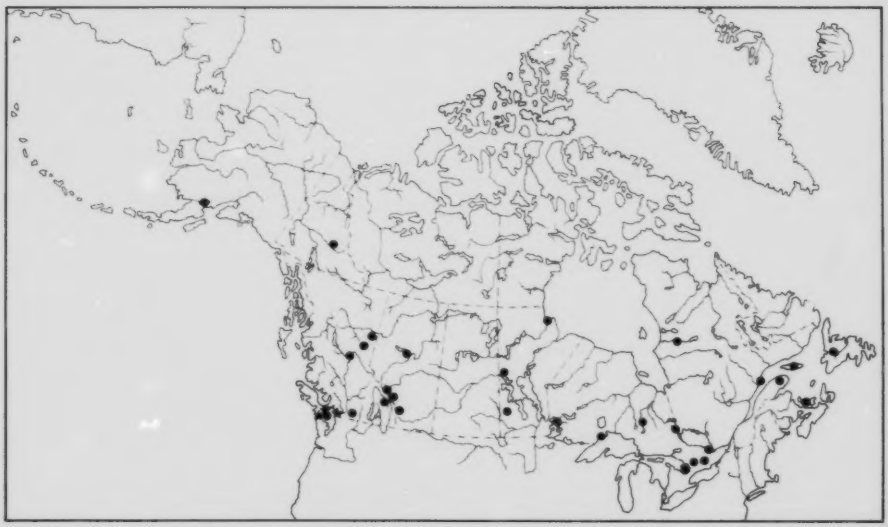
Biology. Bright and Stark (1973).

Adults of this species usually attack young, weakened trees, broken limbs, or small twigs and branches. Parent galleries are oval, circular, or elongate cavities in the cambial region. Eggs are laid in clusters along the edge of the cavity and the larvae mine in any direction in the cambial region. The life history and number of generations are unknown.

Cryphalus ruficollis Hopkins (***approximatus*** Hopkins, ***grandis*** Chamberlin, ***canadensis*** Chamberlin, ***mainensis*** Blackman) (Figs. 78, 122, and 160)

Diagnosis. Length 1.4–1.8 mm. Frons convex, similar to *C. pubescens;* elytral striae usually not impressed, punctures fine, distinctly impressed; elytral declivity steep, striae more obscure than on disk; elytral vestiture consisting of abundant, randomly placed, interstrial, scalelike setae, none of these long and hairlike.

Hosts. *Abies* spp. and *Picea* spp.



Map 52. Distribution of *Cryphalus ruficollis* (●) and *C. pubescens* (★).

Distribution (Map 52). Transcontinental in Canada; northeastern and western United States.

Biology. Very similar to that of *C. pubescens*. Canadian specimens belong to the subspecies *C. ruficollis ruficollis* (Hopkins).

Genus *Hypothenemus* Westwood

Hypothenemus dissimilis (Zimmermann) (*chapuisi* Eichhoff)

Diagnosis. Length 1.6–2.4 mm (♀), 1.3–1.5 mm (♂). Frons convex above eyes, flattened below, surface finely aciculate, punctures moderate in size and depth; anterior margin of pronotum with 2 large, contiguous teeth (♀) or smooth (usually) (♂); elytral striae slightly impressed, punctures small; elytral declivity steep, convex, striae more strongly impressed than on disk; elytral vestiture consisting of sparse rows of long, pointed, interstrial bristles and short, abundant, scalelike interstrial setae.

Hosts. Various broadleaf trees and shrubs.

Distribution. Southern Quebec and Ontario; eastern United States.

Biology. Not investigated.

Genus *Crypturgus* Erichson

Members of *Crypturgus* are distinguishable by their very small size, the two-segmented antennal club (Fig. 79), the antennal club bearing sutures only at the extreme apex (Fig. 79), and the unarmed pronotum and elytral declivity.

The species are of no economic importance.

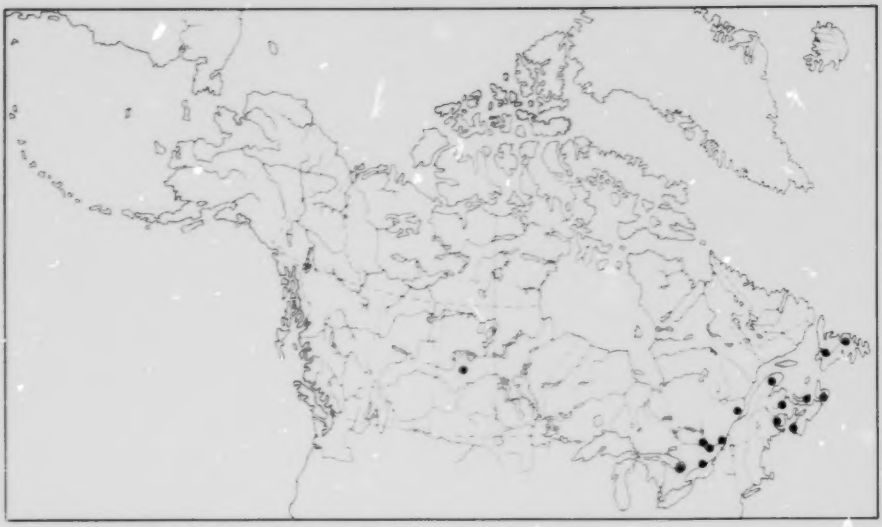
Key to the species of *Crypturgus* in Canada and Alaska

1. Elytral interspaces smooth, brightly shining, sometimes minutely punctured; pronotal punctures moderately large and deep; sutural striae rather strongly impressed on basal one-quarter; only in Eastern Canada ..... ***pusillus* (Gyllenhal)**

Elytral interspaces rugose, opaque, dull, or feebly shining; pronotal punctures small and shallow, indistinct; sutural striae not strongly impressed on basal one-quarter; Alaska to Nova Scotia ..... ***borealis* Swaine**

Crypturgus pusillus (Gyllenhal) (*atomus* LeConte)

Diagnosis. Length 1.0–1.3 mm. Frons convex (♀) or weakly concave above epistoma (♂), surface sparsely pubescent and punctured; pronotum suboval, punctures on dorsal surface moderately large and deep; elytral



Map 53. Distribution of *Crypturgus pusillus*.

interspaces smooth or minutely, sparsely punctured, brightly shining; sutural striae rather distinctly, strongly impressed only on basal one-quarter; declivity unmodified.

Hosts. All eastern species of coniferous trees.

Distribution (Map 53). Eastern Canada; northeastern United States, Eurasia, and Japan.

Biology. Not investigated but probably similar to *C. borealis*.

Crypturgus borealis Swaine (*corrugatus* Swaine) (Figs. 79, 123, and 161)

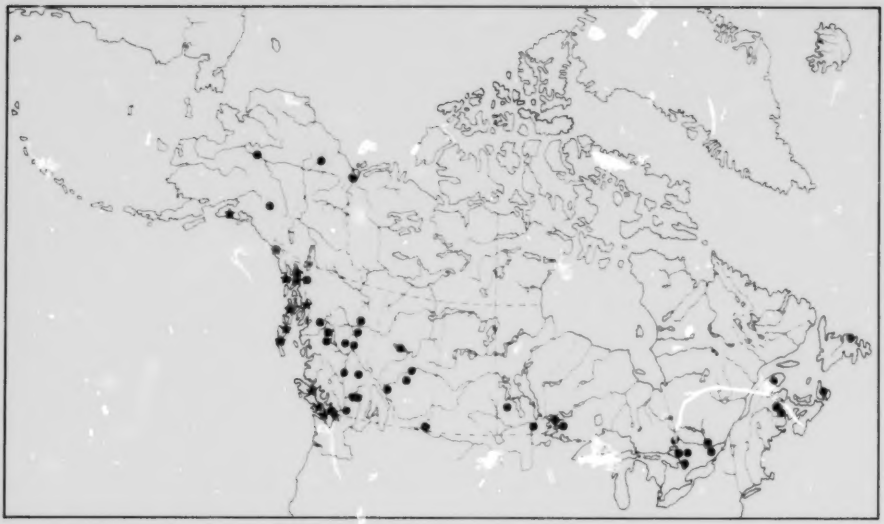
Diagnosis. Length 1.1–1.3 mm. Frons triangularly flattened above epistoma, flatter in ♂; pronotum elongate-oval, punctures on dorsal surface very small, shallow, sometimes almost impossible to see; elytral interspaces rugose, opaque or dull, sometimes feebly shining; sutural striae slightly impressed for entire length; declivity subcircularly spongy (♀) or normal (♂) at apex.

Hosts. All species of coniferous trees in its range.

Distribution (Map 54). Transcontinental in Canada; western United States.

Biology. Bright and Stark (1973).

Galleries start from the main galleries of some larger bark beetle such as *Dendroctonus* spp. or *Ips* spp. They extend about 15–40 mm in the inner bark or



Map 54. Distribution of *Crypturgus borealis* (●) and *Dolurgus pumilus* (★).

cambium. Eggs are deposited along the gallery and the larvae work out into the bark. The larval mines are difficult to follow, but they appear to extend about 40 mm or more and are quite winding. Pupal cells are constructed in the bark.

Genus *Dolurgus* Eichhoff

Dolurgus pumilus (Mannerheim) (Figs. 80, 124, and 162)

Diagnosis. Length 1.6–2.0 mm. Frons strongly convex, flattened above epistoma, surface reticulate and punctured; antennal funicle three-segmented; antennal club with three nearly transverse sutures; pronotum strongly narrowed in front, surface closely punctured; elytral striae with large, regular punctures; elytral interspaces with a uniseriate row of short setae; declivity convex, unmodified.

Hosts. All species of conifers in its range.

Distribution (Map 54). Southeast Alaska and coastal British Columbia; coastal western United States.

Biology. Bright and Stark (1973).

The habits of this species are very similar to those of *Crypturgus* species, that is, the adults use the entrance holes of larger bark beetles to gain access to the inner bark. The egg galleries are minute, very difficult to follow, and have no set pattern progressing in any direction in the inner bark but they do not contact the sapwood.

Genus *Trypodendron* Stephens

Members of this genus are readily distinguishable by the asperate posterior face of the fore tibia, the narrowly and strongly procurved basal area of the antennal club (Fig. 81), the broadly and deeply concave frons and subquadrate pronotum of the male, and the narrow longitudinal proepimeral cavity of the female.

All species in this genus bore into the woody tissues of their host plant, where they feed largely upon the ambrosial fungus that stains the walls of their galleries. Hence they are commonly called ambrosia beetles. They breed in the larger parts (more than 10 cm in diam) of both coniferous and deciduous trees.

The female beetle constructs the entrance gallery. The gallery penetrates the bark and extends to the sapwood, where it may branch several times. The larvae are reared in separate chambers arranged in series above and below the main gallery. As the larvae mature they enlarge these chambers and consequently the chambers are just large enough to accommodate the mature beetles.

Species in this genus can sometimes cause severe economic loss. The black stain produced by the ambrosial fungus that discolors the wood around the burrow and the gallery holes seriously reduce the quality of lumber produced from heavily infested logs.

The genus was revised by Wood (1957).

Key to the species of *Trypodendron* in Canada and Alaska (Modified from Wood (1957))

1. Frons of male armed by a fairly large, sharply pointed, median tubercle between upper half of eyes; posterolateral areas of pronotum more closely and deeply punctured, especially on female; pronotum and elytra dark brown to black, sometimes with a pale area extending from elytral base to declivital margin between interspaces 2 and 7; from *Betula* spp. ..... ***betulae*** **Swaine**

   Frons of male without a tubercle at center; posterolateral areas of pronotum very finely, less closely punctured; color pattern variable; from various hosts, not *Betula* spp. 2

2. From *Populus* spp.; larger, 3.6–4.3 mm (♂) and 3.8–4.6 mm (♀); pronotum of male usually not asperate on median area at base; black at maturity ..... ***retusum*** **(LeConte)**

   From coniferous hosts; smaller, 2.7–3.3 mm (♂) and 3.0–3.7 mm (♀); median area of pronotum asperate to basal margin on both sexes; almost never black at maturity 3

3. Elytral surface smooth and shining, the interspaces usually very minutely and irregularly punctured; apical margin of the elytra appearing broadly rounded from above; elytra usually bicolored, the pattern consisting of five dark stripes alternating with four pale stripes ..... ***lineatum*** **(Olivier)**

Elytral surface rather dull, minutely reticulate; apical margin of the elytra appearing subacuminate from above; elytra brown, the sides usually darker brown ..... ***rufitarsus*** **(Kirby)**

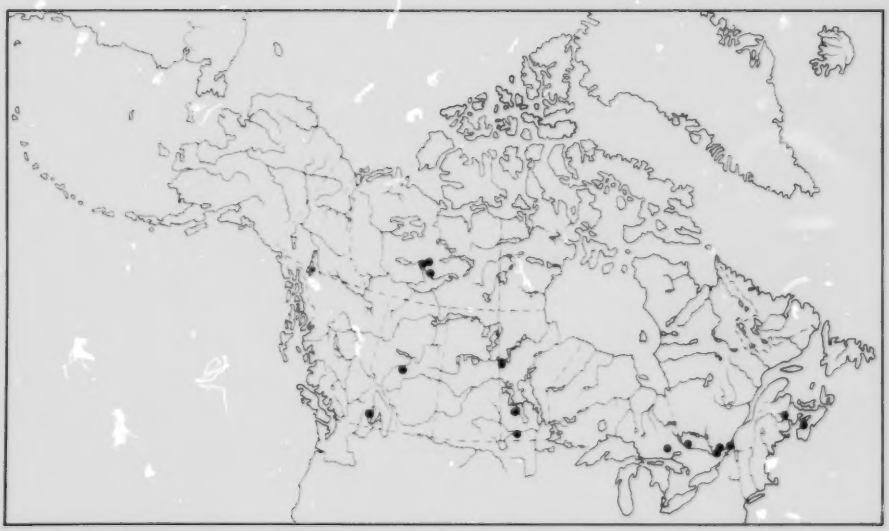
Trypodendron betulae Swaine (Fig. 163)

Diagnosis. Length 3.1–3.5 mm (♀) and 2.7–3.4 mm (♂). Frons convex, surface coarsely, sparsely granulate (♀) or deeply concave with a median tubercle between upper halves of eyes (♂); anterior margin of pronotum rounded, with two large and two small median teeth (♀) or anterior margin straight and unarmed (♂); elytral surface dull, minutely reticulate; apical margin of elytra appearing narrowly rounded from above.

Hosts. *Betula* spp.

Distribution (Map 55). Transcontinental in Canada; eastern United States.

Biology. Not investigated.



Map 55. Distribution of *Trypodendron betulae*.

Trypodendron retusum (LeConte)

Diagnosis. Length 3.8–4.6 mm (♀) and 3.6–4.3 mm (♂). Frons convex, surface sparsely granulate (♀) or deeply concave with lateral margins ornamented by abundant hair (♂); anterior margin of pronotum rounded, with four teeth, the median pair larger (♀) or anterior margin feebly recurved and unarmed (♂); elytral surface smooth and brightly shining; apical margin of elytra appearing subacuminate from above.

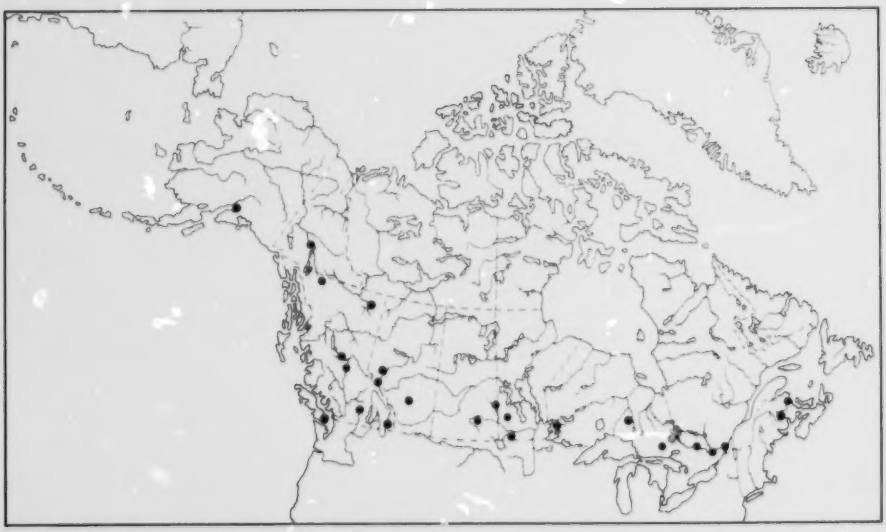
Hostr. *Populus* spp. and *Picea* spp.

Distribution (Map 56). Transcontinental in Canada; northern United States.

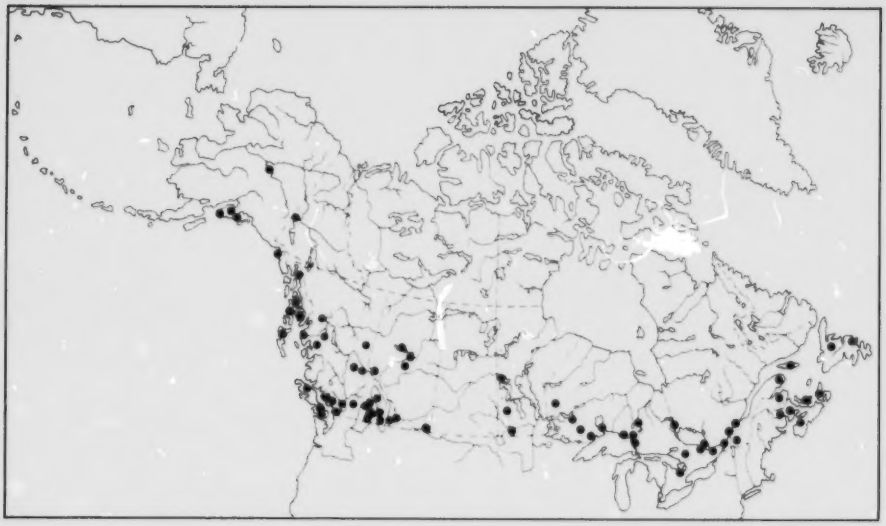
Biology. Hubbard (1897).

Only the work habits of this species are known. Several pairs of beetles use the same gallery, but each pair occupies its own branch galleries. The galleries are not extended deep into the heartwood. The females attend their own broods, which are raised in cradles extending up and down at right angles to the main gallery. The larvae feed on the ambrosial fungus.

Adults of this species prefer to construct their galleries in injured trees that are still green and in recently cut logs.



Map 56. Distribution of *Trypodendron retusum*.



Map 57. Distribution of *Trypodendron lineatum*.

Trypodendron lineatum (Olivier) (***bivittata*** Kirby, ***cavifrons*** Mannerheim, ***vittiger*** Eichhoff, ***borealis*** Swaine) (Figs. 81, 125, and 184)

Diagnosis. Length 3.0–3.5 mm (♀) and 2.7–3.2 mm (♂). Frons convex, surface reticulate with sparse granules (♀) or deeply concave, lateral margins ornamented by abundant hair (♂); anterior margin of pronotum rounded, unarmed (♀) or straight and unarmed (♂); elytral surface smooth, shining; apical margin of elytra appearing broadly rounded from above.

Hosts. Any species of conifer within its range, rarely from *Alnus* spp. or *Betula* spp.

Distribution (Map 57). Transcontinental in Canada; eastern and western United States and Eurasia.

Biology. Bright and Stark (1973) (contains numerous references).

This account of the biology of *T. lineatum* is based almost entirely on studies conducted in British Columbia. Differences in the developmental rate and even in the number of broods or generations per year could well exist in other parts of Canada.

Adults are attracted to windthrown, cut, and dying trees, stumps, and logging slash. Once a few beetles have successfully invaded a host, a powerful secondary attractant produced by the female results in mass invasion of the log.

The flight period extends from late March through August; the heaviest emergence and attack period is in April and May. Later flights consist mainly of reemerging parent adults. The beetles attack logs and larger logging slash in almost any location, including the upper surface of logs in ponds. In exposed

locations, there is some preference for shaded portions of the host. The time of death of the host material affects the time of attack. Hemlock logs felled up to 20 months earlier were attacked by the spring flight. Logs felled after December were not attacked until the second season of exposure. The heaviest spring attacks were in logs felled from October to December of the previous year, and much lighter attacks were made on logs felled from January to May. June to August fallings were free from attack until the following year.

Slash and logging debris from trees felled in autumn and left untreated is an important breeding place for *T. lineatum*. In one area, there was a fourfold increase in the emerging population over the number attacking. Large slash, 2 m long or more and thicker than 30 cm in diam, produced three-quarters of the brood.

Galleries are begun by the female. In Douglas-fir, the galleries are constructed in the sharply defined sapwood 1–7 cm deep. In *Abies* spp., *Tsuga* spp., and probably other hosts, the galleries may penetrate the heartwood 10 cm or more deep. The gallery is usually forked with two, occasionally three branches (Fig. 184) that extend obliquely across the annual rings, but occasionally may follow an annual ring in the sapwood. The entire gallery lies in one plane at right angles to the grain of the wood. The gallery walls become blackened by the ambrosia fungus, *Monilia ferruginea* Mathiesen-Kaarik, within a few weeks following attack. The fungus is introduced by the beetle, hence the name, ambrosia beetle.

Oviposition starts in the first 2 weeks of gallery construction. Eggs are laid singly in niches cut into the end grain of the wood on both sides of the gallery. The larvae hatch within 10 days and as they grow they enlarge the niche to form a larval cradle. The larvae feed on the ambrosial fungus as the fungus matures. Pupation occurs within a month in the larval cradle, and the pupal stadium lasts about 10 days. The young adults emerge from July through September and seek hibernation sites in the duff and bark fissures of standing trees. The optimum hibernation sites are apparently just inside the edge of a forest stand. The hibernation period lasts 7–11 months.

In British Columbia, there is only one generation per year but two or more broods. The second attack, made only by parent adults, usually begins in early July. When the second brood is established, the parent adults and eventually the progeny of this brood emerge and fly to hibernation sites. Adults apparently live longer than 1 year and may produce additional broods.

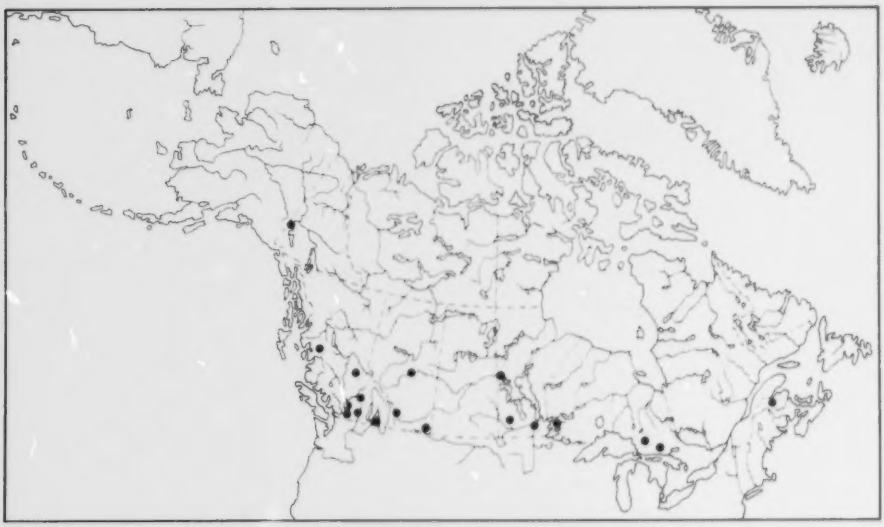
Trypodendron rufitarsus (Kirby) (***ponderosae*** Swaine)

Diagnosis. Length 3.4–3.7 mm (♀) and 2.9–3.2 mm (♂). Frons convex, surface reticulate with fine, sparse granules (♀) or deeply concave with lateral margins ornamented by abundant hair (♂); anterior margin of pronotum rounded, unarmed (♀) or straight and unarmed (♂); elytral surface dull, minutely reticulate; apical margin of elytra appearing subacuminate from above.

Hosts. *Picea* spp., *Pinus* spp., and probably other species of conifers.

Distribution (Map 58). Transcontinental in Canada; western USA.

Biology. Not investigated, but probably similar to *T. lineatum*.



Map 58. Distribution of *Trypodendron rufitarsus*.

Genus *Xyloterinus* Swaine

Xyloterinus politus (Say) (*unicolor* Eichhoff) (Figs. 82, 126, and 164)

Diagnosis. Length 3.3–3.7 mm (♀) and 2.7–2.9 mm (♂). Frons convex in both sexes, less convex in male, surface reticulate and sparsely, coarsely granulate; anterior margin of pronotum rounded, armed with four teeth; proepimeral excavation four times longer than wide; elytral surface smooth, strial punctures small; elytral declivity steep, convex, with longer, more abundant setae.

Hosts. Probably any species of deciduous tree in its range, rarely from coniferous hosts.

Distribution (Map 59). Eastern Canada; eastern United States.

Biology. Chamberlin (1939).

This species, like those in *Trypodendron*, is an ambrosia beetle. The galleries resemble those of *Trypodendron* species except that two larval cavities are excavated above and two below the main gallery, instead of one up and one down as in *Trypodendron*.

Map 59. Distribution of *Xyloterinus politus*.

Genus *Lymantor* Lovendal

Lymantor decipens LeConte (Figs. 127 and 165)

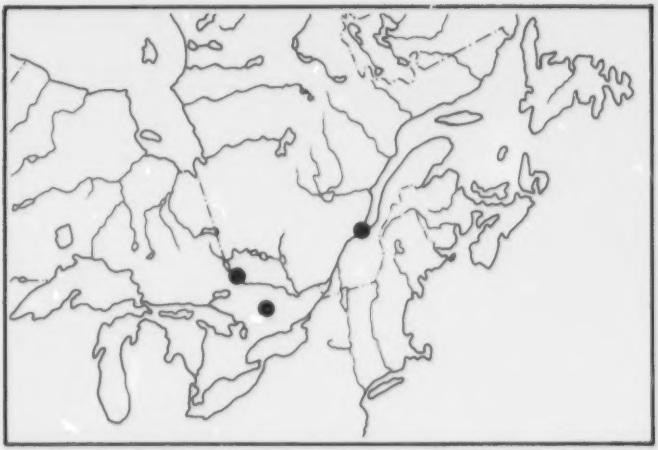
Diagnosis. Length 1.5–2.1 mm. Frons transversely, deeply, concavely impressed above epistoma to near upper level of eyes, surface rather roughly punctured; antennal funicle four-segmented, club nearly circular; pronotal surface asperate on anterior half, strongly punctured on posterior half; elytral striae and interspaces distinctly punctured, punctures of equal size; elytral declivity evenly convex, sutural interspace slightly elevated.

Hosts. *Acer* spp. and *Salix* spp. in Canada; *Carya* spp. and *Pyrus* spp. in United States.

Distribution (Map 60). Eastern Canada; eastern United States.

Biology. Chamberlin (1939).

Adults of this species feed and reproduce in dead dry limbs of various broadleaf trees. The galleries are entirely in the wood, usually very near or at the surface, but sometimes deeper. The egg galleries, usually two or three in number, extend in a longitudinal direction just beneath and parallel to the sapwood. A number of short branches may lie parallel to the surface or may extend obliquely into the wood. The eggs are laid in niches and the larvae bore through the wood in a more or less transverse direction. Both adults and larvae find abundant food in certain wood fungi, which are always abundant in their habitat. The relationship of the beetle to the fungus has not been studied, but it should be an interesting subject for further work.



Map 60. Distribution of *L. mantor decipens*.

Genus *Dryocoetes* Eichhoff

Members of *Dryocoetes* are distinguishable by the five-segmented antennal funicle (Fig. 83), the obliquely truncate antennal club that has one or two curved sutures on the pubescent anterior face and a basal corneous portion occupying more than half the total length (Fig. 83), and the evenly convex pronotum and elytral declivity (Fig. 128).

As far as is known, all species in this genus are polygamous, usually three or four females associated with one male. The male excavates the entrance hole and hollows out the nuptial chamber, where he waits for the females. Each female constructs an egg gallery radiating from the nuptial chamber. Eggs are laid in niches cut into the gallery wall and they are covered with frass.

Most species are of little economic importance. However, *D. confusus* Swaine, in association with the fungus *Ceratocystis dryocoetidis* Kendrick and Molnar, is responsible for heavy losses of alpine fir in British Columbia.

Key to the species of *Dryocoetes* in Canada and Alaska (Modified from Bright (1963))

1. Pronotum widest at or near the middle, sides rather strongly arcuate; proepimeron usually bearing large, shallow punctures 2

   Pronotum widest at base or sides parallel to weakly arcuate; proepimeron may be indistinctly punctured 4

2. Frons of female bearing a dense brush of short, yellowish, hairlike setae; declivity of both sexes steep, flattened, with sutural interspace usually distinctly, sometimes slightly elevated; disk of pronotum finely, densely asperate 3

Frons of female bearing sparsely placed hairlike setae; declivity of both sexes evenly convex, not steep, with sutural interspace feebly elevated; disk of pronotum distinctly punctured ..... ***autographus*** **(Ratzeburg)**

3. Frons of female bearing a very dense brush of hairlike setae, these shorter in center, longer on periphery and nearly concealing the surface of the frons; pronotum finely asperate over entire surface; declivity flattened, sutural interspace distinctly raised; from *Abies* spp. ..... ***confusus*** **Swaine**

Frons of female less densely setose, not concealing the surface of the frons; pronotum sparsely punctured in median area of posterior half of the disk; declivity flattened, sutural interspace less strongly raised; from *Betula* spp. and *Pyrus* spp. ..... ***betulae*** **Hopkins**

4. Declivity with the sutural striae deeply impressed, the punctures large and deep; sutural interspace strongly elevated with median row of granules; pronotum about 1.3 times longer than wide, sides subparallel on posterior two-thirds; elytral punctures large, close, and deep; interspaces narrow on disk, wider on declivity ..... ***granicollis*** **(LeConte)**

Declivity with sutural striae feebly or not impressed; sutural interspace slightly elevated; pronotum less than 1.2 times longer than wide, widest behind middle; elytral punctures smaller, slightly impressed; interspaces as wide or wider than striae 5

5. Body 2.6–3.2 mm long; declivity strongly flattened; female frons densely pubescent, male frons much less dense ..... ***affaber*** **(Mannerheim)**

Body 1.5–2.5 mm long; declivity evenly convex; female frons only slightly more pubescent than male 6

6. Sutural striae slightly impressed on declivity, punctures reduced in size or indistinct; from *Abies* spp. ..... ***schelti*** **Swaine**

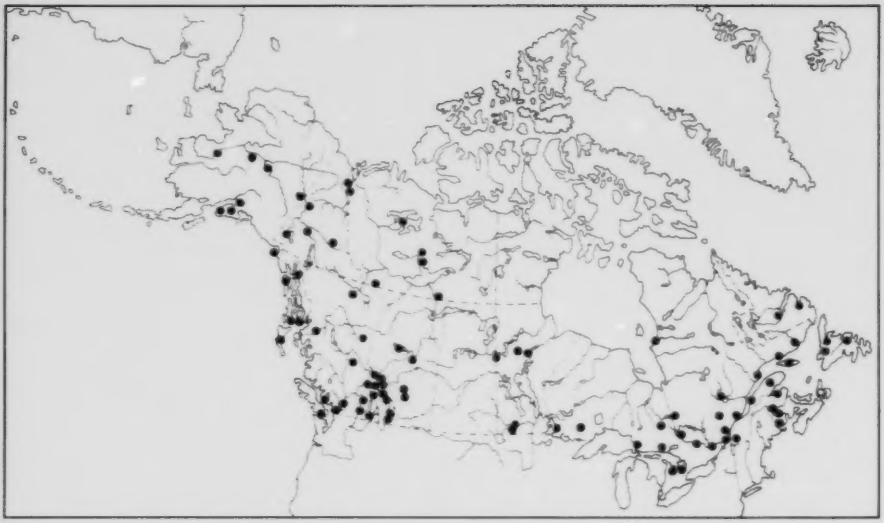
Sutural striae distinctly impressed on declivity, punctures not reduced in size; from *Picea* spp. ..... ***caryi*** **Hopkins**

Dryocoetes autographus (Ratzeburg) (***septentrionis*** Mannerheim, ***americanus*** Hopkins, ***pseudotsugae*** Swaine)

Diagnosis. Length 3.4–5.0 mm. Frons broad, convex, flattened just above epistoma, surface granulate-punctate, with a few, long, hairlike setae; sides of pronotum strongly arcuate, surface strongly punctured; strial punctures large and deep; elytral declivity convex, interspace 2 slightly impressed, all interspaces with a row of fine granules (♀) or without granules (♂).

Hosts. All species of conifers in its range.

Distribution (Map 61). Transcontinental in Canada; eastern and western United States and Eurasia.



Map 61. Distribution of *Dryocoetes autographus*.

Biology. Not investigated.

This species is most often found in the base and roots of dying or injured standing trees or in the bole of felled or windthrown trees.

Dryocoetes confusus Swaine (***abietis*** Hopkins)

Diagnosis. Length 3.4–4.3 mm. Frons convex, surface granulate, with a dense, circular brush of reddish brown to yellowish setae (♀) or only sparsely pubescent (♂); sides strongly arcuate, surface granulate-asperate, lateral and anterior portions asperate; strial punctures small, weakly impressed; elytral declivity convex, interspace 2 impressed, all interspaces granulate-setose, these stronger in female.

Hosts. *Abies lasiocarpa* (less common in other species of *Abies*) and *Picea engelmannii*.

Distribution (Map 62). British Columbia and Alberta; western United States.

Biology. Bright (1963) and Mathers (1931).

D. confusus is the most economically important species in this genus. In association with the fungus *Ceratocystis dryocoetidis* this species is a chronic problem in Western Canada. The actual monetary loss is not known, but its host tree, alpine fir, occurs at more inaccessible high elevations and consequently the tree loses its commercial value.

In British Columbia, adults of *D. confusus* emerge from hibernation in the latter part of June and they fly until late July. New trees are attacked soon after the beetles emerge and the tunnels for the first brood are constructed. Eggs are laid in these tunnels until late August, when the beetles construct feeding and hibernation tunnels. The male hibernation tunnel extends from the nuptial chamber, and the female hibernation tunnel is a continuation of the egg gallery; these areas are recognizable by the absence of egg niches. Activity begins anew in the spring when the female beetles continue their egg galleries, laying eggs in the freshly cut portions. Egg laying continues until late June or early July, when the parent adults either emerge and attack a new tree or die in the galleries. The first brood of eggs hatches in late August and the winter is spent as young larvae. These larvae mature during the next summer, when they pupate and transform to new adults in August. However, these adults do not emerge until the following spring, thus giving a 2-year life cycle.

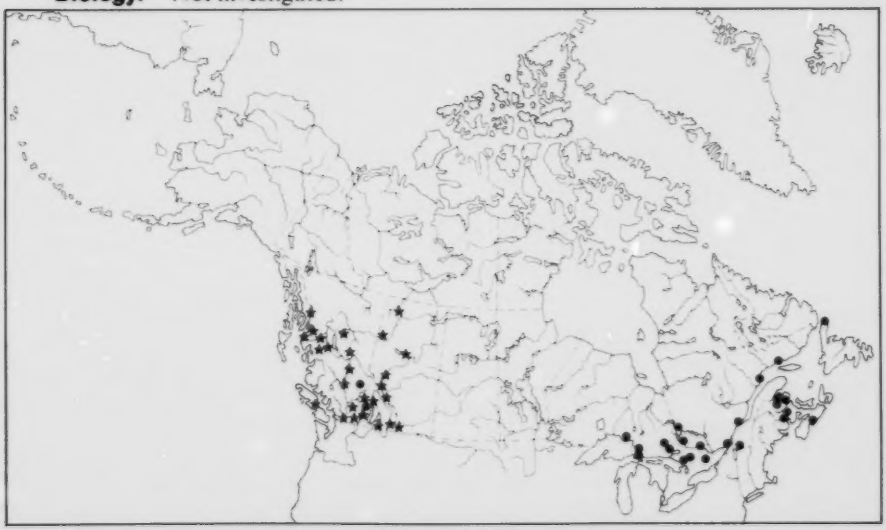
Dryocoetes betulae (Hopkins) (***liquidambaris*** Hopkins)

Diagnosis. Length 2.8–4.5 mm. Frons broad, convex, surface granulate, with a dense, circular brush of yellowish, hairlike setae (♀) or sparsely pubescent (♂); sides of pronotum strongly arcuate, surface asperate except on posterior portion near median line; strial punctures large, distinctly impressed; elytral declivity convex, interspaces 1 and 3 slightly elevated, granulate, more accentuated in male, interspace 2 impressed.

Hosts. *Betula* spp.

Distribution (Map 62). Eastern Canada and British Columbia; eastern United States.

Biology. Not investigated.



Map 62. Distribution of *Dryocoetes confusus* (★) and *D. betulae* (●).

Dryocoetes granicollis (LeConte)

Diagnosis. Length 2.3–3.0 mm. Frons flattened or slightly concave with an indistinct median line, surface minutely granulate, sparsely pubescent; sides of pronotum parallel on posterior two-thirds, surface subgranulate and punctate; strial punctures large, deep; elytral declivity steep, sutural striae deeply impressed, sutural interspace strongly elevated and distinctly granulate, other interspaces less strongly elevated and less strongly granulate.

Hosts. *Picea* spp.

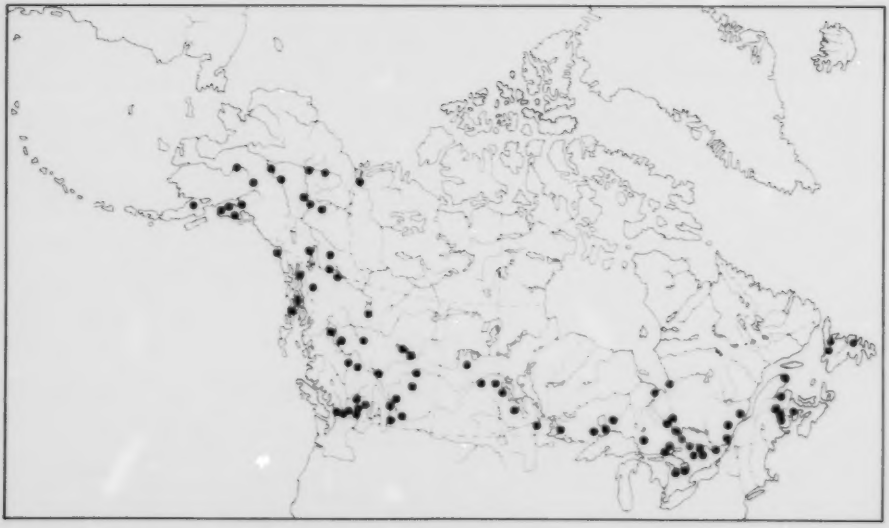
Distribution (Map 64). Quebec and New Brunswick; northeastern and eastern United States south to North Carolina.

Biology. Not investigated.

Dryocoetes affaber (Mannerheim) (***pubescens*** Swaine, ***piceae*** Hopkins) (Figs. 83, 128, and 166)

Diagnosis. Length 2.5–3.3 mm. Frons flattened, surface granulate-punctate, with a moderately dense brush of yellowish hairlike setae (♀) or sparsely pubescent (♂); sides of pronotum arcuate, converging toward anterior margin, surface granulate on basal areas, asperate on anterior and lateral areas; strial punctures large, moderately impressed; elytral declivity flattened, interspaces 1 and 3 slightly elevated, granulate, more accentuated in male.

Hosts. Chiefly *Picea* spp. and *Pinus* spp.; also *Larix* spp. and *Abies* spp.



Map 63. Distribution of *Dryocoetes affaber*.

Distribution (Map 63). Transcontinental in Canada; eastern and western United States.

Biology. Keen (1952).

The adults construct a central nuptial chamber from which usually three egg galleries radiate.

Dryocoetes schelti Swaine

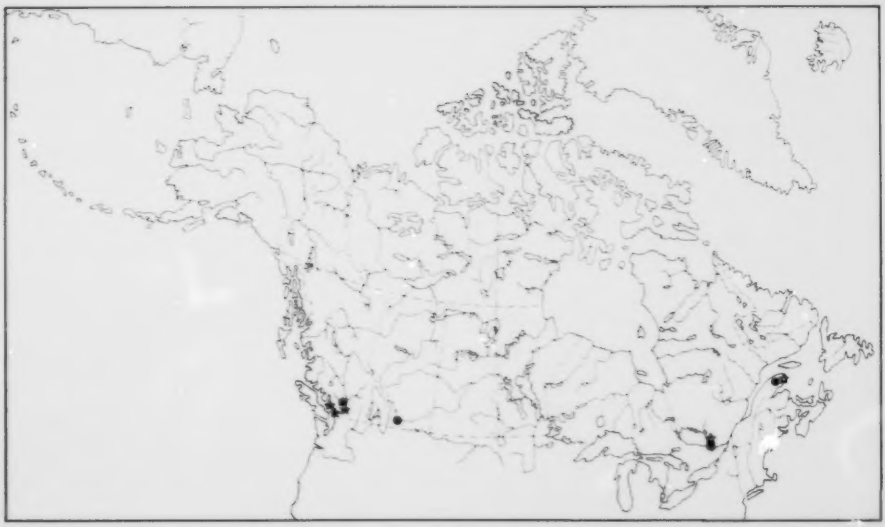
Diagnosis. Length 2.0–2.5 mm. Frons convex, transversely impressed above epistoma, the impression divided by a weak, longitudinal median line, surface granulate-punctate, setose; sides of pronotum slightly arcuate, surface granulate, asperate on anterior and lateral portions; strial punctures large, moderately impressed; elytral declivity convex below, flattened on upper portion, sutural interspace slightly raised, interspaces finely granulate, granules smaller or absent in male.

Host. *Abies lasiocarpa*.

Distribution (Map 64). British Columbia; western United States.

Biology. Not investigated.

Adults of this species breed in the lower portion of the bole in small, suppressed trees of less than 20 cm in diam.



Map 64. Distribution of *Dryocoetes granicollis* (◎), *D. schelti* (★), and *D. caryi* (●).

Dryocoetes caryi Hopkins

Diagnosis. Length 2.1–2.7 mm. Frons convex above, flattened above epistoma, divided by a prominent, impunctate, longitudinal, median line, surface granulate-punctate, setose; sides of pronotum arcuate, surface granulate, asperate on anterior portion; strial punctures moderately large, impressed; elytral declivity flattened, sutural striae weakly impressed, other striae with weak to obsolete punctures, interspaces not elevated, granulate, granules smaller in male.

Hosts. *Picea* spp.

Distribution (Map 64). Transcontinental in Canada; eastern and western United States.

Biology. Not investigated.

Adults of this species are evidently quite rare. They breed in small, weakened, shaded-out, or suppressed spruce trees.

Genus *Xyleborus* Eichhoff

Members of *Xyleborus* are recognizable by the 5-segmented antennal funicle (Fig. 84), the obliquely truncate antennal club (Fig. 84), the asperate pronotum, which is convex in front (♀) or flattened or concave in front (♂), the metepisternum visible to its posterior extremity, and the meso- and metathoracic tibiae broadly dilated to slightly beyond the middle, then gradually narrowing to the apex (Fig. 55).

The males are usually much smaller than the females, flightless, and seldom collected. They usually differ from the females quite radically in appearance.

All the species in this genus are ambrosia beetles. The adults bore into the woody tissues of their host and feed largely on the ambrosial fungus that lines the walls of their galleries. They breed in all sizes and types of material, except roots, of both coniferous and deciduous trees and shrubs. Usually only unhealthy or newly felled trees or shrubs are attacked. In Canada, these species are of little economic importance.

The entrance tunnel is constructed by the female. The tunnel penetrates the bark and extends into the sapwood for up to 5 cm. The tunnel may end in an enlarged chamber, as in *X. saxeseni* Ratzeburg, or it may branch several times, as in most of the other species of *Xyleborus*. Eggs are laid loose along the gallery wall and, when the larvae emerge, they wander about feeding on the ambrosial fungus. The larvae do not occupy cradles as do the species in the tribes Xyloterini and Corthylini. Mature larvae construct their pupal cells along the sides of the gallery. Young adults may stay in the galleries for a while, feeding on the fungus. Successive generations of beetles are sometimes produced in the same host plant if the moisture content remains favorable for the growth of the fungus. The parental entrance hole is used for the emergence of the new

generation. The young female beetles mate before they leave the gallery, because the males are unable to fly and they die within the parental nest.

A key to the North American species is given in Bright (1968).

Key to the species of *Xyleborus* (females only) in Canada (Modified from Bright (1968))

1. Pronotum wider than long, coarsely asperate in front; body stout, less than 2.7 times longer than wide 2

   Pronotum longer than wide, more finely asperate in front; body slender, more than 2.7 times longer than wide 4

2. Ridge of declivital interspace 7 with 3–5 well-developed teeth, declivity steep (Fig. 28) ..... ***obesus* LeConte**

   Ridge of declivital interspace 7 smooth; declivity sloping 3

3. Length 2.5–2.7 mm; anterior margin of pronotum with three or four erect asperities; declivital interspaces with very fine granules (Fig. 29) ..... ***sayi* (Hopkins)**

   Length 3.2–3.7 mm; anterior margin of pronotum with six to eight erect asperities; declivital interspaces with larger granules (Fig. 30) ..... ***dispar* (Fabricius)**

4. Scutellum conical; lower margin of declivity, beginning about interspace 7, bearing a series of pointed tubercles, the longest tubercle at end of interspace 2 (Fig. 31) ..... ***saxeseni* (Ratzeburg)**

   Scutellum flat, lower margin of declivity acute or rounded, smooth 5

5. Declivity steep, flattened; striae 1 and 2 on declivital face distinct, diverging from suture; two distinct teeth on striae 1, two smaller teeth in interspace 3; upper margin of declivity bordered by at least one tubercle in all interspaces (Fig. 32) ..... ***celsus* Eichhoff**

   Declivity convex or sloping, with tubercles on interspaces 1 or 3, or both, never with teeth on striae 1 6

6. Interspace 1 with a small tubercle at upper level of declivity; declivital interspace 3 slightly elevated, with a large tooth in middle and a small tooth at upper level; declivity slightly sulcate between interspaces 1 and 3 (Fig. 33) ..... ***ferrugineus* (Fabricius)**

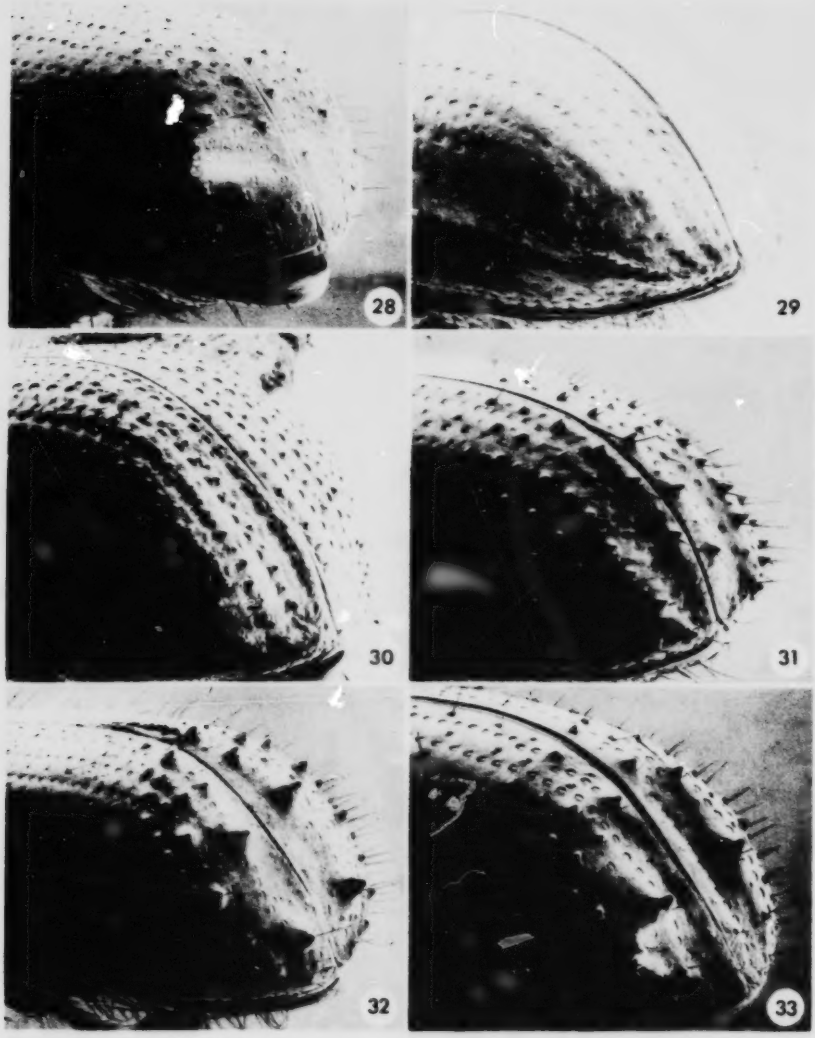
   Declivital interspaces 1 and 3 with equal-sized teeth; declivity not sulcate 7

7. Declivity steep, somewhat flattened; tubercles on interspaces 1 and 3 very small (Fig. 34); posterior portion of pronotum alutaceous, dull ..... ***xylographus* (Say)**

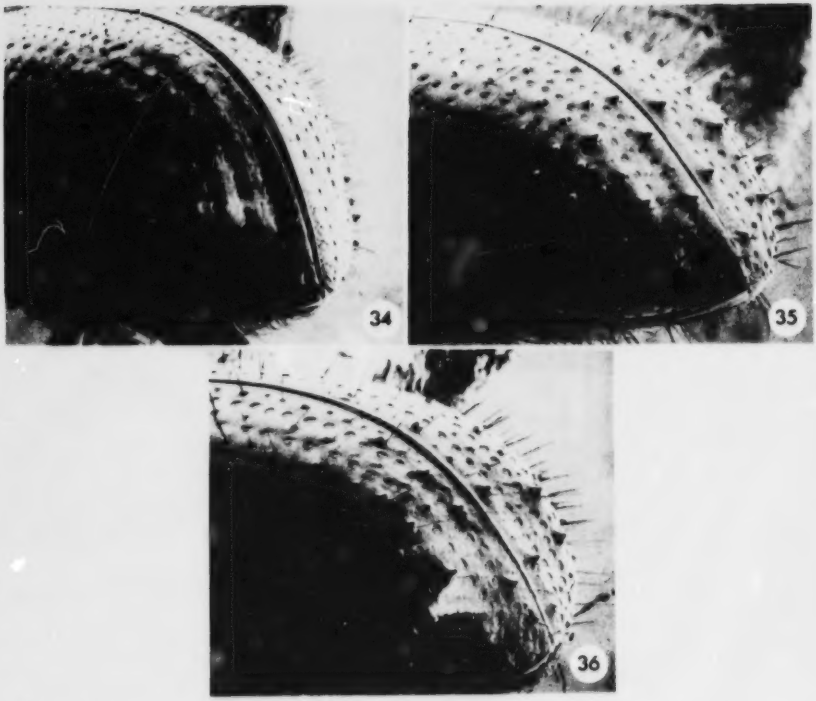
   Declivity sloping or oblique and slightly flattened; tubercles on interspaces 1 and 3 small; posterior portion of pronotum shining 8

8. Declivity dull, opaque, broadly sloping; posterior portion of pronotum smooth, shining; declivital granules small but conspicuous (Fig. 35) ..... ***affinus*** **Eichhoff**

Declivity shining, oblique, and slightly flattened; posterior portion of pronotum with large punctures, surface between punctures appearing minutely scratched or irregularly punctate; declivital granules smaller (Fig. 36) ..... ***pubescens*** **Zimmerman**



Figs. 28–33. Declivities of *Xyleborus* spp. 28, *X. obesus;* 29, *X. sayi;* 30, *X. dispar;* 31, *X. saxeseni;* 32, *X. celsus;* 33, *X. ferrugineus.*



Figs. 34–36. Declivities of *Xyleborus* spp. 34, *X. xylographus*; 35, *X. affinus*; 36, *X. pubescens*.

The following descriptions of the species of *Xyleborus* pertain to females only, except for the measurements.

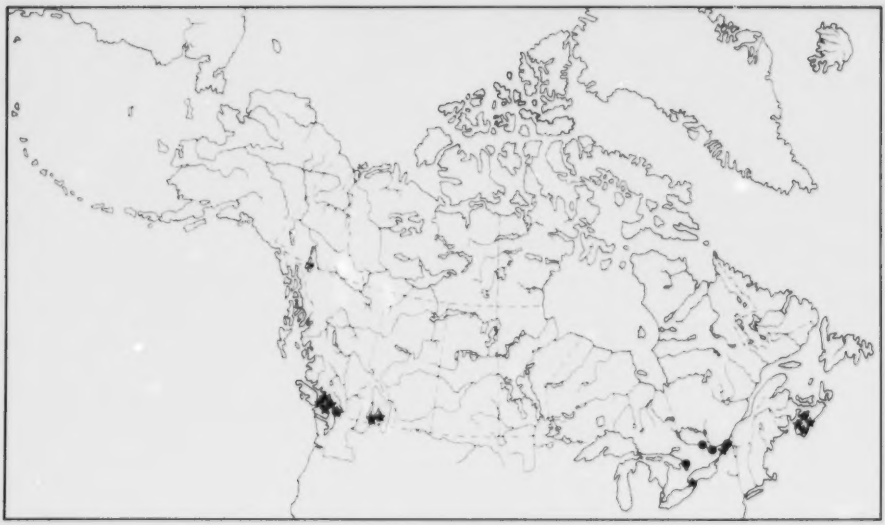
Xyleborus obesus LeConte (***serratus*** Swaine, ***populi*** Swaine) (Fig. 28)

Diagnosis. Length 3.3–3.7 (♀) and 1.7–2.0 (♂). Frons slightly impressed above epistoma on each side of a faint longitudinal carina, punctures on surface large, shallow; anterior margin of pronotum with two to four prominent asperities; strial punctures large, impressed; declivity convex, striae 1 more deeply impressed than others, interspaces smooth, shining, ridge of interspace 7 elevated with three to five small, prominent teeth.

Hosts. Probably all species of deciduous trees in its range.

Distribution (Map 65). Eastern Canada; northeastern and eastern United States.

Biology. Not investigated.



Map 65. Distribution of *Xyleborus obesus* (●) and *X. dispar* (★).

Galleries are constructed in the outer 1-cm portion of the wood and are biramous. Each tunnel is constructed by a single female, who occupies it with her brood.

Xyleborus sayi (Hopkins) (*neardus* Schedl) (Figs. 29, 133, and 171)

Diagnosis. Length 2.5–2.7 mm (♀) and 1.3–1.6 mm (♂). Frons minutely granulate, very faintly punctured over the surface, longitudinal elevation faint; anterior margin of pronotum with three or four prominent asperities; strial punctures large, closely placed; declivity convex, striae 1 slightly more impressed than others, interspaces faintly granulate, ridge of interspace 7 slightly elevated, usually smooth and may be broadly undulating.

Hosts. Probably all species of deciduous trees in its range.

Distribution (Map 66). Eastern Canada; eastern United States.

Biology. Not investigated.

Xyleborus dispar (Fabricius) (*pyri* Peck, *swainei* Drake) (Fig. 30)

Diagnosis. Length 3.2–3.7 mm (♀) and 1.8–2.1 mm (♂). Frons minutely reticulate, opaque, slightly impressed above epistoma on each side of a faintly elevated longitudinal carina; anterior margin of pronotum with six to eight prominent asperities; strial punctures large, closely placed; declivity convex, interspaces 1 and 3 slightly elevated, all interspaces faintly granulate, ridge of interspace 7 acute, elevated, and unbroken.

Hosts. Probably all species of deciduous trees in its range. Infrequently recorded (probably in error) from some species of conifers.

Distribution (Map 65). Eastern Canada and coastal British Columbia; Pacific Northwest and eastern United States, Europe, and Asia.

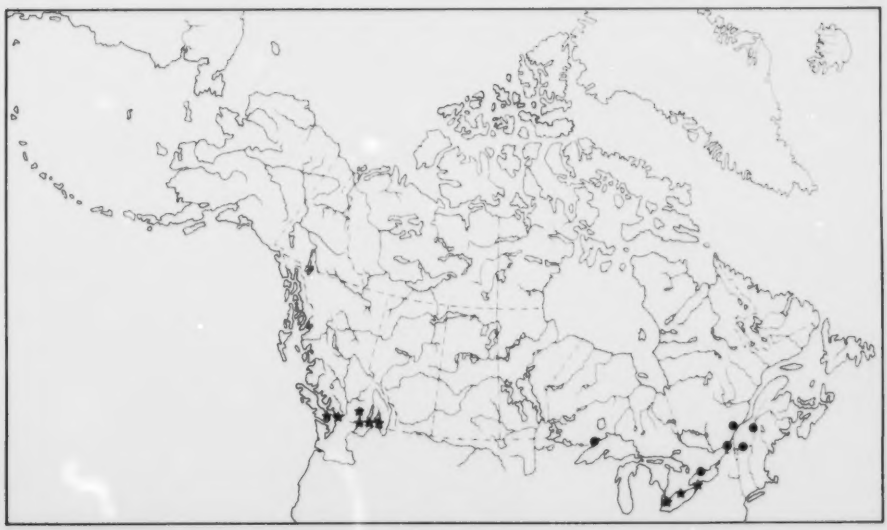
Biology. Beal and Massey (1945) and Mathers (1940).

This species is often referred to in the early literature as the pear-blight beetle and occasionally as the shot-hole borer. This latter name is now the official common name for another insect, *Scolytus rugulosus*.

The beetle prefers to attack weakened or dying trees, but is capable of attacking apparently healthy trees. It has been known to kill fruit trees in British Columbia, especially when the trees are growing on poor soil, have been recently transplanted, or are under stress of some kind.

The galleries penetrate the wood for a short distance, then follow a circular course parallel to the annual rings of the host. In small limbs, the galleries take the form of a spiral or corkscrew, with short longitudinal side galleries. No larval cradles are constructed; the larvae feed in the main gallery.

In British Columbia, adults attack in March and April. Some of the attacking population may leave the first host and make a second attack, but apparently most of them die in the galleries after the eggs have been laid. The new brood reaches the adult stage about mid-July. New adults apparently remain in the parental gallery system throughout the remainder of the summer and the following winter, emerging in early spring of the following year. There is one generation and one brood per year in British Columbia.



Map 66. Distribution of *Xyleborus sayi* (●) and *X. saxeseni* (★).

Xyleborus saxeseni (Ratzeburg) (***quercus*** Hopkins, ***pecanis*** Hopkins, ***floridensis*** Hopkins, ***arbuti*** Hopkins, ***tsugae*** Swaine, ***libocedri*** Swaine) (Figs. 31 and 84)

Diagnosis. Length 2.0–2.2 mm (♀) and 1.5 mm (♂). Frons minutely reticulate, punctures distinct but faint, longitudinal line very faint; anterior margin of pronotum devoid of asperities; scutellum conical, acute; strial punctures impressed, larger than those in interstriae; elytral interspaces smooth, granulate toward declivity; declivity dull, reticulate, interspaces 1 and 3 slightly elevated, with a row of tubercles, apical portion of interspace 9 forming lower margin and bearing several acute tubercles.

Hosts. Various species of deciduous trees, also *Pinus* spp. and *Tsuga* spp.

Distribution (Map 66). Southeastern and southwestern Canada; United States and Holarctic region.

Biology. Prebble and Graham (1957) and Schedl (1961).

Adults of this species attack large dying trees. The adults mine straight in toward the pith and then turn in a radial direction and form a large cave. The entire surface of the walls of this chamber are covered with ambrosial fungus.

Up to 48 eggs are deposited freely in the radial gallery and in the chamber. The larvae and young adults wander about feeding freely on the fungus and helping extend the chamber. All stages overwinter in the logs.

Xyleborus celsus Eichhoff (***biographus*** LeConte) (Fig. 32)

Diagnosis. Length 3.8–4.5 mm (♀) and 2.3–2.7 (♂). Frons shining, rather densely punctured, with a median, longitudinal smooth space; anterior margin of pronotum unarmed; strial punctures large, closely placed; elytral interspaces smooth, with small punctures; declivity abrupt, steep, with two large, acute teeth on striae 1, interspace 1 widened with several smaller teeth on upper level, interspace 3 with small teeth throughout.

Hosts. *Carya* spp.

Distribution. Not yet known from Canada, but probably occurs in southern Ontario; known from eastern United States.

Biology. Baker (1972).

Galleries of this species extend directly into the wood 12–18 mm deep, then branch once or several times.

Xyleborus ferrugineus (Fabricius) (***fuscatus*** Eichhoff, ***impressus*** Eichhoff, ***retusicollis*** Zimmerman, ***nyssae*** Hopkins, ***soltani*** Hopkins) (Fig. 33)

Diagnosis. Length 2.1–3.0 mm (♀) and 2.2–2.3 mm (♂). Frons minutely reticulate, punctures sparse and faintly impressed, longitudinal line

faintly elevated, smooth; anterior margin of pronotum smooth; strial punctures moderate in size, impressed; elytral interspaces smooth, shining, sparsely punctured; declivity convex, sloping, interspace 1 with several small teeth at upper level, interspace 3 with a large, prominent tooth in the middle, interspaces 4, 5, and 6 with several small teeth.

Hosts. Probably all species of deciduous trees in its range. Rarely from *Pinus* spp.

Distribution. Not yet recorded from Canada but probably occurs in southern Ontario; known from eastern United States and all tropical and subtropical areas of the world.

Biology. Beal and Massey (1945), Browne (1962), and Schedl (1961).

Galleries extend about 5 cm into the wood, then they branch once or several times. The brood feeds on the ambrosial fungus that lines the walls of the main gallery and its branches. Only dead or dying trees or newly felled timber is attacked.

There appears to be no published information on the development and the length of the life cycle of members of this species.

Xyleborus xylographus (Say) (***inermis*** Eichhoff, ***planicollis*** Zimmerman, ***canadensis*** Swaine) (Fig. 34)

Diagnosis. Length 2.5–2.8 mm (♀) and 2.2–2.4 mm (♂). Frons minutely reticulate, shining, punctures shallow and scattered, longitudinal carina indicated by a broad, smooth, slightly elevated line; anterior margin of pronotum unarmed; strial punctures large, impressed; interspaces smooth, with numerous punctures; declivity convex, flattened, opaque, interspaces 1 and 3 slightly elevated, each with two or three minute granules, interspace 2 slightly granulate.

Hosts. Chiefly from *Quercus* spp.; also from other species of deciduous trees.

Distribution (Map 67). Eastern Canada; eastern United States.

Biology. Baker (1972).

Galleries run obliquely across the grain of the wood at 2.5 cm or deeper. Eventually they branch and the arms follow the grain.

Xyleborus affinus Eichhoff (Figs. 35 and 55)

Diagnosis. Length 2.3–2.8 mm (♀) and 1.7–2.0 mm (♂). Frons minutely reticulate, shining, punctures large, closely placed, longitudinal carina weak to obsolete; anterior margin of pronotum unarmed; strial punctures moderate in size, slightly impressed; interspaces smooth, shining, sparsely punctured; declivity broadly convex, opaque, dull, all interspaces with one to four small granules, these larger on interspaces 1 and 3 and sometimes absent on 2.

Hosts. Various species of deciduous trees.

Distribution. Not known from Canada, but probably could be found in southern Ontario; known from eastern United States and in most tropical and subtropical areas of the world.

Biology. Not investigated.

Galleries consist of elongate tunnels from which many transverse galleries branch.

Xyleborus pubescens Zimmerman (Fig. 36)

Diagnosis. Length 2.4–2.8 mm (♀) (♂ unknown). Frons minutely reticulate, opaque, punctures sparse, weakly impressed, longitudinal carina evident, extending to above upper level of eyes; anterior margin of pronotum unarmed; posterior portion of pronotum appearing minutely scratched between the large punctures; strial punctures large, distinctly impressed; interspaces smooth, shining, punctures numerous; declivity steep, shining but sometimes with opaque patches, interspaces 1 and 3 weakly elevated, bearing three to five small granules.

Hosts. Not recorded, but probably could be found in various species of deciduous trees.

Distribution (Map 67). Southern Ontario; eastern United States.

Biology. Not investigated.

Map 67. Distribution of *Xyleborus xylographus* (●) and *X. pubescens* (★).

Genus *Pityogenes* Bedel

The members of this genus are distinguishable by the deeply excavated frons of the female (Figs. 37 and 38), the compressed antennal club bearing two sutures on the posterior face (Fig. 85), two or three pairs of elongated teeth on the male declivity, and the short, obtuse prosternal intercoxal piece.

Adults of the species in this genus are found in fresh fallen branches or shaded-out lower branches of various species of pines, and, occasionally, spruces. They are of no economic importance, but should be considered beneficial because they help break down woody material and assist other decay-causing organisms.

The gallery pattern is typically star-shaped with four to six or more egg galleries radiating from a central nuptial chamber (Figs. 185 and 186). The eggs are deposited in niches cut into the walls of the egg galleries, and the larvae mine away from the egg galleries. The tunnels score the sapwood and the inner bark.

Key to the species and subspecies of *Pityogenes* in Canada

1. Elytral declivity convex, bearing three small teeth on each side of suture in both sexes, these teeth much larger in the males; pronotum narrowly rounded anteriorly; female frontal pit undivided 2

   Elytral declivity convex (♀) or oblique (♂), bearing two small tuberculate-like teeth plus several small granules on each side of suture in the female and two large teeth on each side of the suture in the male, the upper pair of teeth hook-shaped; pronotum broadly rounded anteriorly; female frontal pit divided or undivided 3

2. Surface between punctures on pronotum lateral to median line usually dull, opaque, punctures abundant; diameter of frontal pit on frons of female about half the distance between eyes; Western Canada ..... ***fossifrons*** **(LeConte)**

   Surface between punctures on pronotum lateral to median line usually smooth, brightly shining, punctures sparse; diameter of frontal pit on frons of female less than one-third of the distance between eyes; Eastern Canada west to Saskatchewan ..... ***hopkinsi*** **Swaine**

3. Body 2.9–3.5 mm long; frontal pit of female large, deep, and undivided (Fig. 37); lowest declivital pair of teeth placed on a short, elevated ridge; in *Pinus ponderosa* and related pines ..... ***carinulatus*** **(LeConte)**

   Body shorter than 2.8 mm; frontal pit of female small, shallow, and divided into two equal parts by a longitudinal carina (Fig. 38); lowest declivital pair of teeth not arising on an elevated ridge; in *Pinus banksiana, P. contorta, P. resinosa,* and related pines and *Picea* spp. 4

4. Dorsal surface of pronotum lateral to median line shining, smooth or minutely punctured between punctures; obvious pronotal punctures small, more than twice the diameter of a puncture apart; area just above and lateral to pit on frons of female brightly shining, punctured, and sometimes weakly rugose; in *Pinus banksiana*, *P. resinosa*, and *Picea* spp. ..... ***plagiatus plagiatus*** **(LeConte)**

Dorsal surface of pronotum lateral to median line dull, opaque, reticulate, and more strongly granulate between punctures; obvious pronotal punctures larger, almost touching, separated by a distance equal to or much less than the diameter of a puncture; area just above and lateral to pit on frons of female less brightly shining, bearing isolated granules; in *Pinus contorta* ..... ***plagiatus knechteli*** **Swaine**

Pityogenes fossifrons (LeConte)

Diagnosis. Length 2.0–2.5 mm. Frons convex, bearing a deep, circular pit between eyes (♀) or a faint longitudinal carina (♂), the diameter of the pit of the female equal to about half the distance between the eyes; anterior margin of pronotum narrowly rounded; pronotal surface on each side of median line dull, with abundant punctures; elytral declivity convex, bearing three teeth on each side of suture, these teeth small and acute (♀) or large with upper pair flattened laterally (♂).

Hosts. *Pinus monticola;* rarely *P. contorta.*

Distribution (Map 68). Southwestern Canada; western United States to central California and eastern Arizona.

Biology. Not investigated but probably very similar to *P. hopkinsi.*

Pityogenes hopkinsi Swaine (Fig. 185)

Diagnosis. Length 1.8–2.3 mm. Frons as in *P. fossifrons* except diameter of frontal pit less than one-third of the distance between eyes; anterior margin of pronotum narrowly rounded; pronotal surface on each side of median line brightly shining, with sparse punctures; elytral declivity as in *P. fossifrons.*

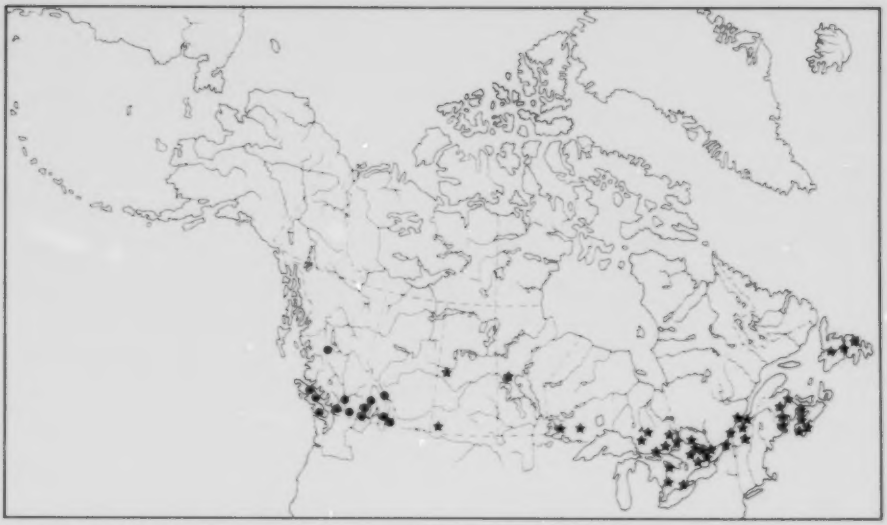
Hosts. *Pinus strobus;* rarely *P. resinosa*, *P. banksiana*, and *Picea* spp.

Distribution (Map 68). Eastern Canada and as far west as Saskatchewan; eastern United States.

Biology. Blackman (1915).

The adults of this species prefer the thin-barked tops and limbs of recently dead or dying white pines. Large populations are produced in slash.

Winter is passed as young adults, larvae, or pupae. Adults emerge from their overwintering burrows and attack new host material in early spring, about



Map 68. Distribution of *Pityogenes fossifrons* (●) and *P. hopkinsi* (★).

late April or early May. The males attack first; they construct the entrance tunnel and the nuptial chamber. From three to five females join the male, and after they have mated, each female excavates her own egg tunnel. The gallery system is star-shaped, with three to five egg galleries radiating from the central nuptial chamber (Fig. 185).

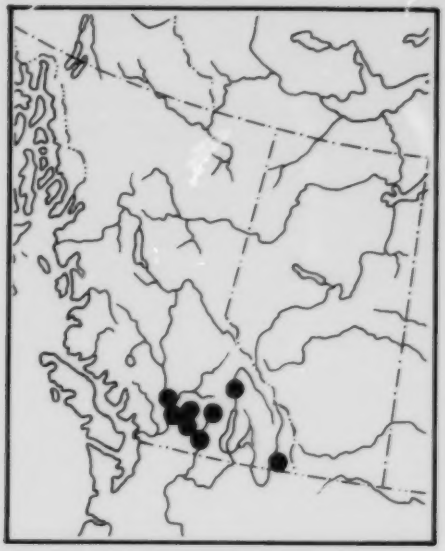
The egg gallery is usually about 2.5 cm long and contains up to 60 eggs. Larvae hatch in 5–10 days and they have five instars. A complete generation takes 28–43 days.

This species is of no economic importance. In fact, it could be considered beneficial because of its role in hastening the decay process. However, adults sometimes attack and kill small sickly pines and they may be responsible for causing considerable damage.

Pityogenes carinulatus (LeConte) (***hamatus*** LeConte) (Fig. 37)

Diagnosis. Length 2.6–3.5 mm. Frons convex, with a deep, very large, longitudinally oval pit (♀) or devoid of pit and granulate-punctate (♂); anterior margin of pronotum broadly rounded; pronotal surface on each side of median line punctured; elytral declivity convex, with two small, acute teeth on each side of suture (♀) or declivity flattened, abrupt, with upper margin bearing a curved, hook-shaped tooth and a smaller, straight, acute granule on lower margin on each side of suture (♂).

Host. *Pinus ponderosa.*



Map 69. Distribution of *Pityogenes carinulatus*.

Distribution (Map 69). Southern British Columbia; western United States.

Biology. Bright and Stark (1973).

The gallery pattern is the typical star-shape with its four or five (rarely up to ten) egg galleries radiating from a central nuptial chamber.

Pityogenes plagiatus plagiatus (LeConte) (***lecontei*** Swaine)

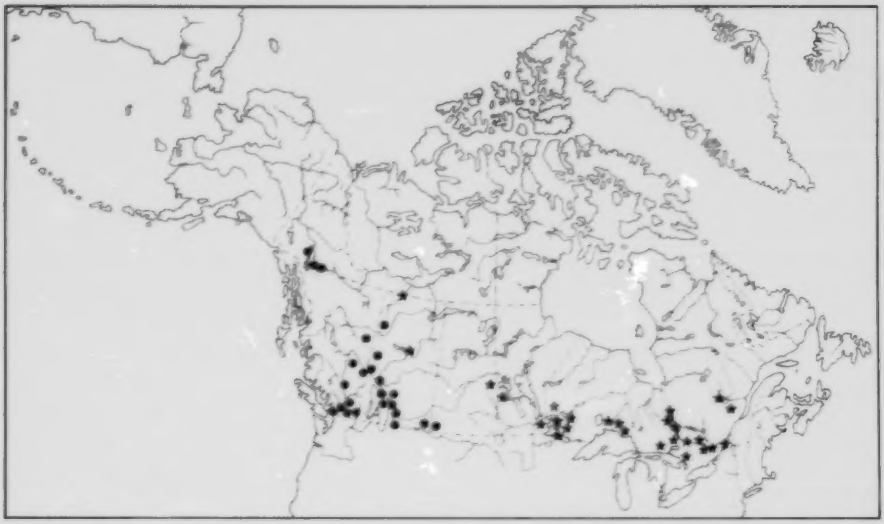
Diagnosis. Length 1.7–2.4 mm. Frons convex, with two close, rather small, elongate pits (♀) or surface devoid of pits, punctate-granulate (♂); anterior margin of pronotum broadly rounded, posterior portion shining, finely punctured; elytral declivity essentially as in *P. carinulatus* except lowest pair of teeth not arising on an elevated ridge.

Hosts. *Pinus banksiana*, *P. resinosa*, and *Picea* spp.

Distribution (Map 70). Eastern Canada as far west as northern Alberta; eastern United States.

Biology. Not investigated.

The gallery pattern is typical of species in this genus.



Map 70. Distribution of *Pityogenes plagiatus plagiatus* (★) and *P. p. knechteli* (●).

Pityogenes plagiatus knechteli Swaine (Figs. 38, 85, 129, 167, and 186)

Diagnosis. Length 2.0–3.0 mm. Frons as in *P. p. plagiatus;* pronotum as in *P. p. plagiatus* except surface of posterior area less brightly shining and punctures larger; elytral declivity as in *P. p. plagiatus.*

Host. *Pinus contorta.*

Distribution (Map 70). Western Canada; also in the Cypress Hills in southwestern Saskatchewan and southeastern Alberta, overlaps distribution of *P. p. plagiatus* in northern Alberta; western United States.

Biology. Bright and Stark (1973).

P. p. knechteli is associated with slash and stems that are small in diameter. In Alberta, first attacks are in late May. Young adults from this first brood are still active in mid-July and they continue feeding under the bark until fall. By September, the second brood is in the pupal and late larval stage, and a few young adults are present. Therefore, there is one and a partial second generation or two full generations per year.

The gallery pattern is typical of species in this genus (Fig. 186). From four to six egg galleries radiate from the central nuptial chamber. The egg galleries and the nuptial chamber are constructed in the inner bark, scoring the sapwood only slightly. The larval mines are almost entirely in the inner bark until the larvae reach maturity. Pupation takes place in small pits in the sapwood, in shallow excavations within the inner bark, or in pupal cells in the inner bark.

Genus *Orthotomides* Wood

Orthotomides lasiocarpa (Swaine) (Fig. 86)

Diagnosis. Length 1.9–2.3 mm. Frons convex or flattened, densely punctate-granulate and densely pubescent (♀) or transversely impressed above epistoma and deeply punctured (♂); antennal club thickened at base but not obliquely truncate, with three sutures on anterior face; elytral declivity abrupt, interspace 2 impressed, interspaces 1 and 3 of equal height, bearing small teeth.

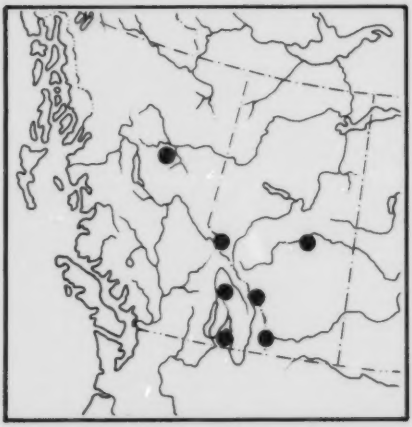
Hosts. *Abies lasiocarpa*, *Picea engelmannii*, and *Larix* spp.

Distribution (Map 71). Western Canada; western United States.

Biology. Not investigated.

Genus *Pityokteines* Fuchs

Members of this genus are characterized by long and abundant setae of the frons and anterior portion of the pronotum of the female (Fig. 130), the obliquely truncate antennal club, which is devoid of sutures on the posterior face (Fig. 87), long and acutely tapered prosternal intercoxal piece, and large declivital teeth, especially in the male (Fig. 40).



Map 71. Distribution of *Orthotomides lasiocarpa*.

Key to the species of *Pityokteines* in Canada

1. Female frons and anterior margin of pronotum densely pubescent; in *Abies* spp. or *Pseudotsuga* spp. 2

   Female frons and anterior margin of pronotum sparsely pubescent; in *Pinus* spp. ..... ***ornatus*** **(Swaine)**

2. Moderately stout species; pronotum only slightly longer than wide; elytral interspaces sparsely punctured on disk; declivital teeth larger 3

   Slender species; pronotum distinctly longer than wide; elytral interspaces closely punctured on disk; declivital teeth very small to minute ..... ***minutus*** **(Swaine)**

3. Occurs in British Columbia; elytral striae finely impressed on disk; interstrial punctures smaller than strial punctures; frons of male transversely impressed above epistoma ..... ***elegans*** **Swaine**

   Occurs from northeastern Alberta eastward; elytral striae not impressed on disk; interstrial punctures similar in size to strial punctures; frons of male longitudinally carinate ..... ***sparsus*** **(LeConte)**

Pityokteines ornatus (Swaine) (Figs. 39 and 40)

Diagnosis. Length 2.2–2.8 mm. Frons convex, surface granulate and punctate, densely pubescent; elytral striae distinctly impressed, punctures very large, placed in regular rows; interspaces sparsely, finely punctured, each interspace with a row of longer setae; declivity steep, with two pairs of rather large, curved teeth and a pair of small acute granules at upper level (♂) or with three pairs of much smaller, acute granules (♀).

Host. *Pinus ponderosa*.

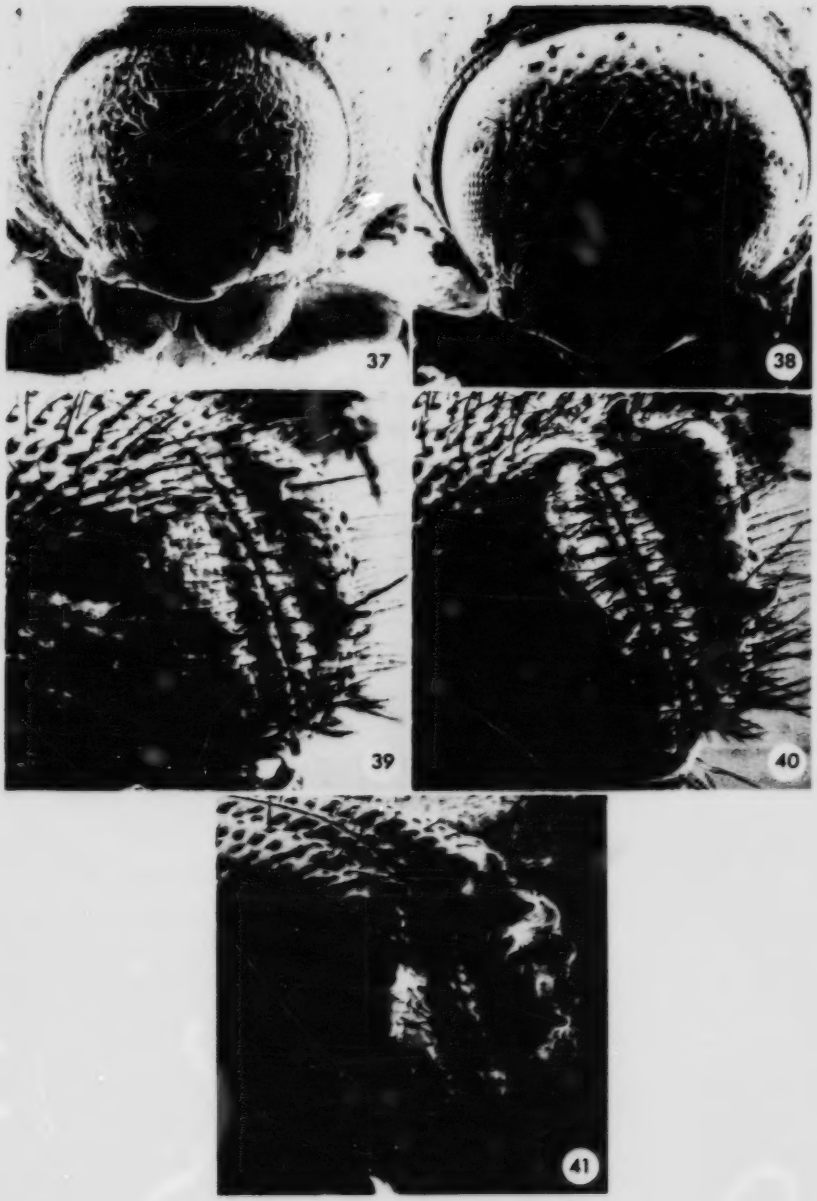
Distribution (Map 72). Southern British Columbia; western United States.

Biology. Not investigated.

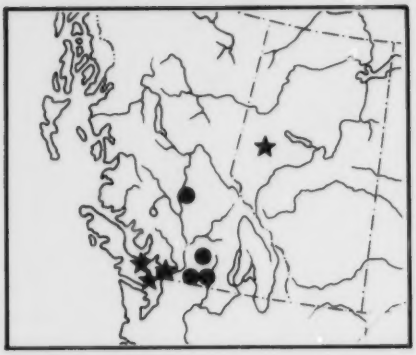
Pityokteines minutus (Swaine) (*Jasperi* Swaine) (Fig. 87)

Diagnosis. Length 2.0–2.4 mm. Frons convex, surface densely granulate-punctate, sparsely pubescent (♂) to very densely pubescent, the setae long, incurved on upper level (♀); anterior margin of pronotum bearing long setae (♀); elytral striae weakly impressed, punctures moderate, placed in regular rows; elytral interspaces with numerous punctures and each interspace with a row of long setae; declivity steep, striae 1 impressed, sutural interspace elevated, teeth on lateral areas small (♂) or minute to obsolete (♀).

Hosts. *Abies lasiocarpa* and *Pseudotsuga menziesii*.



Figs. 37–41. 37 and 38, Frons of *Pityogenes* spp. 37, *P. carinulatus* ♀; 38, *P. plagiatus knechteli* ♀. 39 and 40, Declivities of *Pityokteines ornatus*. 39, ♀; 40, ♂. 41, Declivity of *Orthotomicus caelatus*.

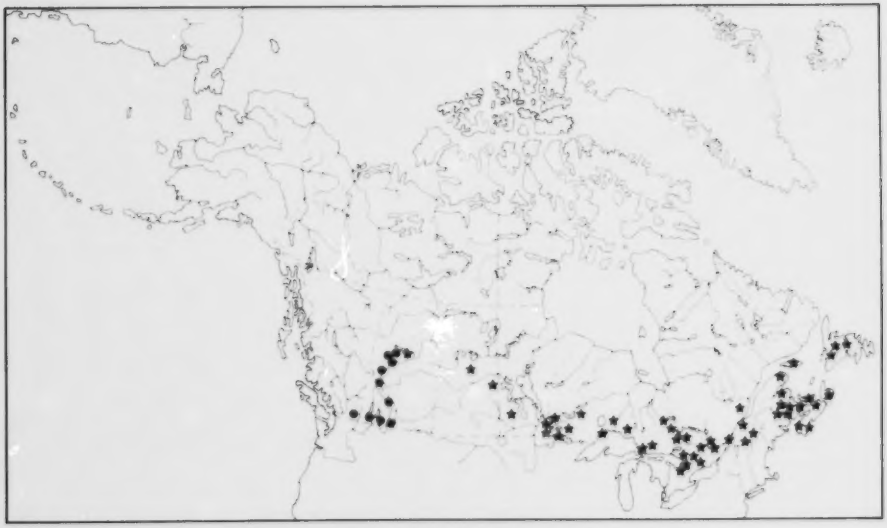


Map 72. Distribution of *Pityokteines ornatus* (●) and *P. elegans* (★).

Distribution (Map 73). Southern British Columbia and western Alberta; western United States.

Biology. Chamberlin (1939).

Adults of this species usually attack the tops and limbs of dying trees or the trunk of suppressed or cut small trees. The galleries are star-shaped with four to six or more egg galleries radiating from the nuptial chamber.



Map 73. Distribution of *Pityokteines minutus* (●) and *P. sparsus* (★).

Pityokteines elegans (Swaine)

Diagnosis. Length 2.1–2.8 mm. Frons convex, surface densely granulate-punctate, rather sparsely pubescent (♂) or densely pubescent, the setae long, incurved on upper level (♀); anterior margin of pronotum bearing long setae (♀); elytral striae finely impressed on disk punctures moderate, in regular rows; elytral interspaces rather sparsely punctured, the punctures smaller than strial punctures and armed with long setae; declivity steep; abrupt (♂) or more convex with striae 1 impressed (♀), lateral areas with three pairs of large teeth, the second pair of teeth larger (♂) or with three pairs of small, nearly equal-sized teeth (♀).

Hosts. *Abies grandis*, and other species of *Abies*.

Distribution (Map 72). Western Canada; western United States.

Biology. Not investigated but probably very similar to *P. minutus*.

Pityokteines sparsus (LeConte) (***punctipennis*** LeConte, ***balsameus*** LeConte) (Figs. 130 and 168)

Diagnosis. Length 2.1–2.5 mm. Frons flattened (♀) to convex (♂), surface obscurely punctured, with a weak, longitudinal carina (♂) or very densely pubescent (♀); anterior margin or pronotum bearing long setae (♀); elytral striae not impressed on disk, punctures moderate, in regular rows; elytral interspaces more abundantly punctured, the punctures similar in size to strial punctures; declivity similar to *P. elegans*, except teeth of both sexes somewhat smaller.

Host. *Abies balsamea*.

Distribution (Map 73). Throughout the northern coniferous forest from northeastern Alberta to Newfoundland; northeastern United States.

Biology. Chamberlin (1939).

Very similar to other species in the genus. The gallery consists of a very irregular shaped chamber from which several egg galleries radiate. These egg galleries are mostly excavated in a horizontal direction, across the grain of the wood. The egg niches are large, quite widely spaced, and only a few are found in each egg gallery. The egg galleries are usually 2.5–3.0 cm long. The larvae work mostly with the grain of the wood.

Attacks are usually made in the tops and limbs of injured or fallen trees, but they may extend to the lower bole in fallen trees.

Genus *Orthotomicus* Ferrari

Orthotomicus caelatus (Eichhoff) (***vicinus*** LeConte, ***punctipennis*** LeConte) (Figs. 41, 59, 88, 131, and 169)

Diagnosis. Length 2.4–3.2 mm. Frons convex, usually transversely impressed above epistoma, surface granulate with a smooth median line; antennal funicle five-segmented, club longer than wide, obliquely truncate with three arcuate sutures; elytral striae and interstriae punctured in regular rows; elytral declivity abrupt, lateral margins weakly to strongly granulate, face with three large, acute bulbous granules (♂) or with small, slender granules (♀), lower margin more or less distinctly acute.

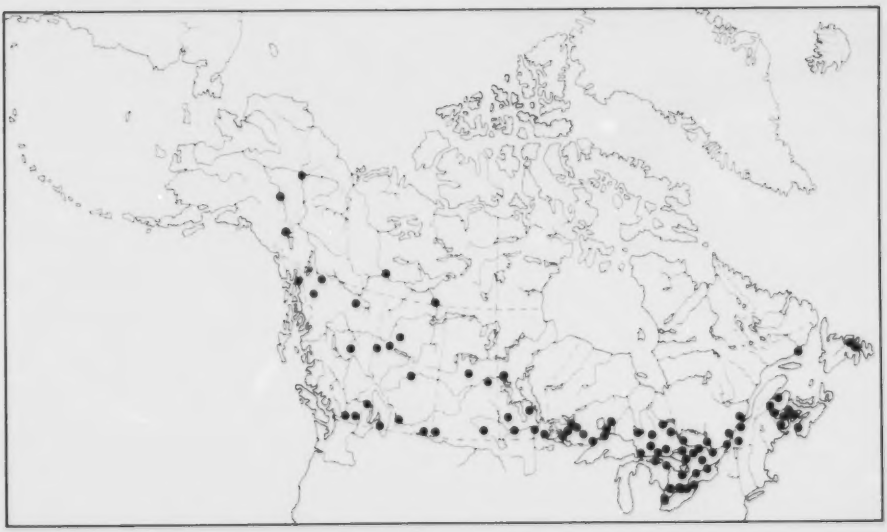
Hosts. Probably all species of conifers in its range.

Distribution (Map 74). Transcontinental in Canada; eastern and western United States.

Biology. Chamberlin (1939, 1958).

This is one of the most common species of Scolytidae in pines and spruces in Canada and Alaska. Adults of this species breed mainly in the bole of standing or fallen recently dead trees, or in stumps of cut trees.

Adults are polygamous and construct a radiate gallery system. The egg galleries are usually short, and from two to six eggs are deposited in each egg



Map 74. Distribution of *Orthotomicus caelatus*.

niche. The adult galleries and larval mines are similar to those constructed by *Pityogenes plagiatus knechteli*, but the mines are slightly deeper in the sapwood and the radial character of the gallery is not so evident. Pupation takes place in chambers constructed in the inner bark, or within pits in the sapwood. The entrance hole to the pits is cut straight into the inner bark, whereas adults of *P. p. knechteli* tend to slope their entrance hole. The holes are filled with boring dust, and the pupal cell is an elongated chamber running parallel with the grain of the wood.

This species is seldom of economic importance as an enemy of trees, and, in fact, it could be considered beneficial because it attacks and kills weakened or shaded-out trees thereby opening the stand. The insect is found almost entirely in fresh stumps or in the lower bole of standing or prostrate trees. It is very seldom found in slash.

Genus *Ips* De Geer

Members of this genus are most easily recognizable by the concave elytral declivity bearing three to six spines on each lateral margin (Figs. 42–51) and the concavity separated from the apical margin of the elytra by a definite, horizontal platelike extension distinct from the elytral margin. Also, the antennal club is flattened, circular to oval, with 3 visible sutures varying from straight to acutely angulate (Figs. 89–94). Other characters are given in the key to genera.

More information has been written about the species in this genus than in any other genus of Scolytidae except possibly *Dendroctonus*. The species of *Ips* have been the subjects of studies on pheromones, attractants, nematodes, mites, emergence, development, muscle generation, sound production, toxicology, taxonomy, and general biology (Bright and Stark (1973)).

The galleries of the species of *Ips* are constructed in the phloem-cambial region of tops, large limbs, and boles of standing or fallen trees. Some species are aggressive tree killers but most of them attack trees already injured or weakened. The galleries consist of a central nuptial chamber from which several egg galleries fork or radiate. Usually each species constructs a distinctive gallery pattern.

Key to the species of *Ips* in Canada and Alaska

1. Elytral declivity with three spines on each lateral margin (Figs. 42 and 43) 2

   Elytral declivity with more than three spines on each lateral margin 4

2. Sutures of antennal club broadly sinuate to nearly straight (Fig. 89) .... ***latidens*** **(LeConte)**

   Sutures of antennal club strongly arcuate (Fig. 90) 3

3. Caudal half of pronotum finely, densely punctured, diameter of each puncture 0.03 mm or less; caudal margin of each puncture raised giving the surface a granulate appearance; in *Picea sitchensis* ..... ***concinnus*** **(Mannerheim)**

Caudal half of pronotum sparsely punctured, diameter of each puncture 0.04 mm or more; surface not granulate, at least on caudal one-quarter of disk; in *Pinus* spp. ..... ***mexicanus*** **(Hopkins)**

4. Elytral declivity with four spines on each lateral margin (Figs. 44–49) 5

Elytral declivity with more than four spines on each lateral margin (Figs. 50 and 51) .. 13

5. Declivital spine 3 broad, compressed, emarginate at the tip (Fig. 44); body large, about 6 mm long ..... ***emarginatus*** **(LeConte)**

Declivital spine 3 not appreciably broadened or compressed, not emarginate at tip; body smaller, usually shorter than 6 mm 6

6. Elytral interspaces impunctate on disk; declivital spine 3 of males subcapitate, subacute at tip, often slightly bent ventrad (Figs. 45 and 46); spine 3 of female similar to spine 2 with an emarginate ridge joining them; primarily from pines 7

Elytra with one or more interspaces on the disk uniseriately punctate-setose (except *perturbatus*); declivital spine 3 strongly capitate and acute at tip; declivital armature of male and female usually similar (except *I. perroti* (Fig. 47)); primarily from spruce 9

7. Sutures of antennal club strongly, acutely angled at middle (Fig. 91) 8

Sutures of antennal club bisinuate, not strongly or acutely angled at middle (Fig. 92) ..... ***pini*** **(Say)**

8. Pronotal width 1.96 mm (SD = 0.11); frons with a distinct carina connecting a median frontal tubercle to a well-developed epistomal tubercle; usually in ponderosa pine ..... ***integer*** **(Eichhoff)**

Pronotal width 1.77 mm (SD = 0.11); carina connecting frontal tubercle and epistomal tubercle reduced or absent; usually in lodgepole pine ..... ***plastographus*** **(LeConte)**

9. Sutures of antennal club straight or nearly so (Fig. 93); declivital spine 3 of male capitate, acute at tip; declivital spine 3 of female similar to spine 2 (Fig. 47) ..... ***perroti*** **Swaine**

Sutures of antennal club distinctly bisinuate (Fig. 94); declivital armature of male and female similar 10

10. Declivital spine 3 capitate, conical and acute at tip, lower part of frons of female not elevated or protuberant and without brushes of setae 11

Declivital spine 3 sometimes capitate but not conical and acute at tip; lower part of frons of female slightly inflated to strongly protuberant, pubescence variable 12

11. Elytral interspaces 2–5 impunctate at least on basal half; females without stridulating mechanism ..... ***perturbatus*** **(Eichhoff)**

Elytral interspaces uniseriately punctate-setose throughout; females with stridulating mechanism (a median longitudinal carina on the occiput) ..... ***woodi*** **Thatcher**

12. Declivital spine 3 short, triangular in outline rather than capitate (Fig. 48); frons of female very smooth and shining, glabrous or pubescent, with or without fine punctures; frons of male with more numerous granules and punctures . ***borealis*** **Swaine**

Declivital spine 3 subcapitate or cylindrical, subacute or rounded at tip (Fig. 49); frons of female weakly to strongly protuberant, variously pubescent .... ***tridens*** **(Mannerheim)**

13. Declivity with five spines on each lateral margin (Fig. 51) 14

Declivity with six spines on each lateral margin (Fig. 50) ..... ***calligraphus*** **(Germar)**

14. Eastern Canada; elytral interspaces impunctate on basal half of disk ***grandicollis*** **(Eichhoff)**

Western Canada; elytral interspaces uniseriately punctate-setose throughout .... ***montanus*** **(Eichhoff)**

Ips latidens (LeConte) (***longidens*** Swaine, ***guildi*** Blackman) (Figs. 42 and 89)

Diagnosis. Length 2.7–3.5 mm. Frons flattened, shining, granulate-punctate, sparsely pubescent; antennal club circular, sutures weakly sinuate to nearly straight (Fig. 42); elytral interspaces punctured and setose; declivity steep, lateral margin with three teeth, the lower tooth long and acute, middle tooth broad, acute on upper level, upper tooth located in interspace 2 small, curved, and acute (Fig. 89).

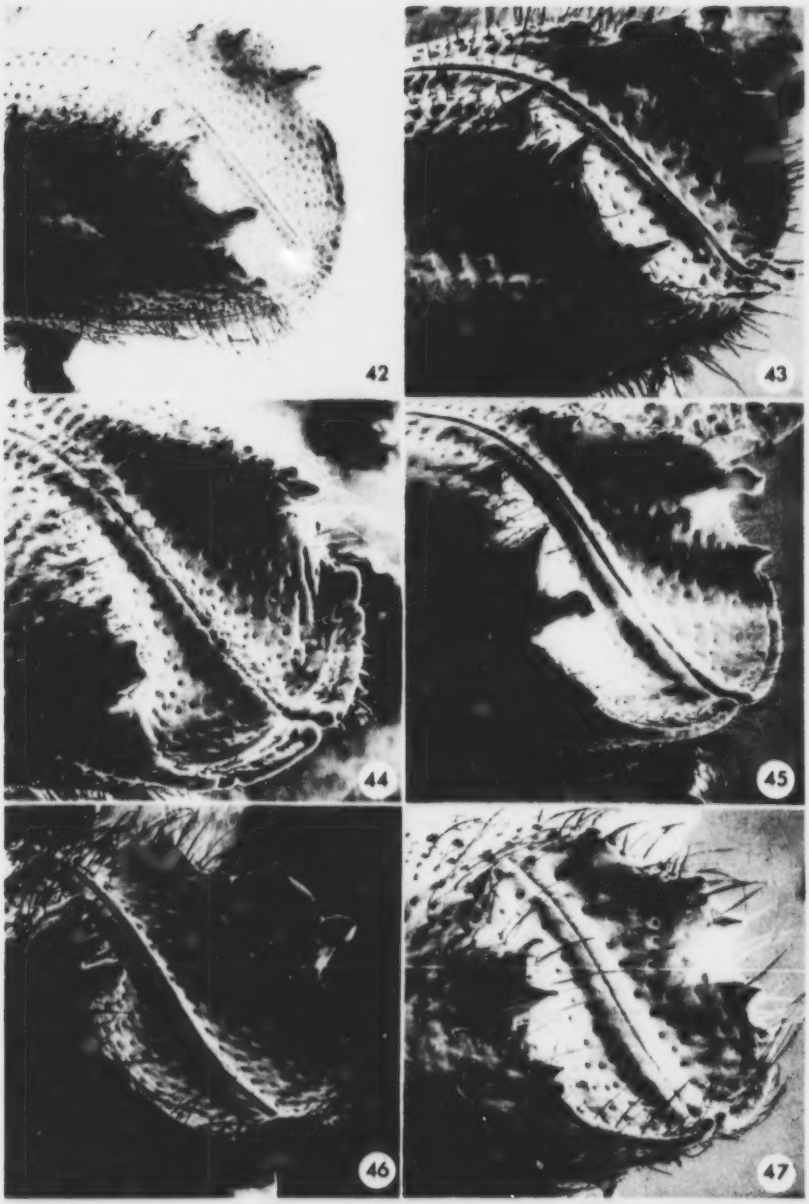
Hosts. *Pinus* spp.; also *Pseudotsuga menziesii* and *Tsuga canadensis*.

Distribution (Map 75). Eastern and Western Canada; eastern and western United States.

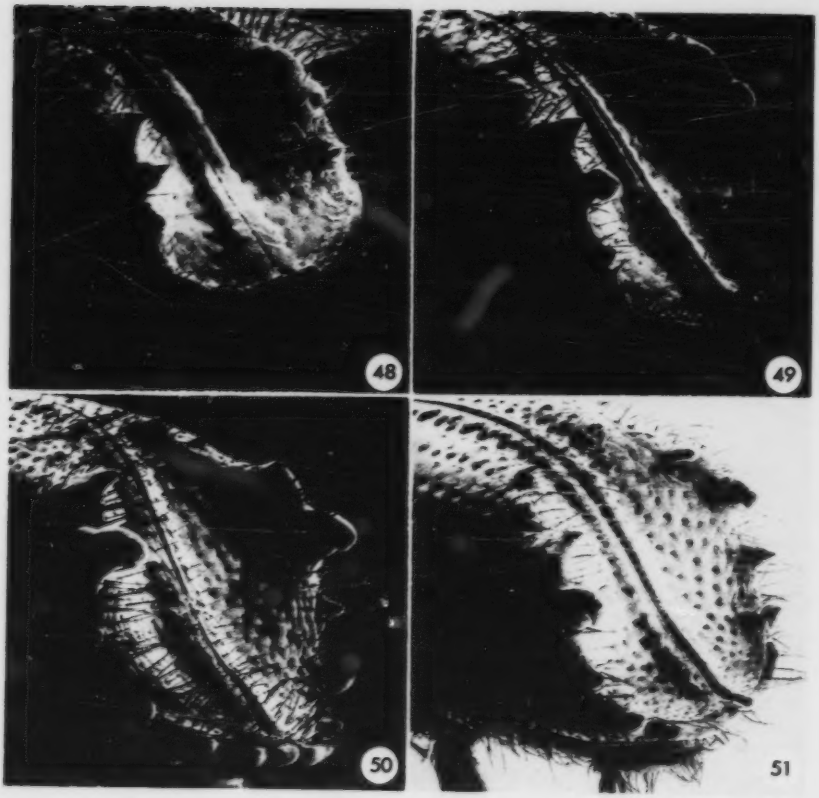
Biology. Blackman (1919), Bright and Stark (1973), and Chamberlin (1939).

Adults usually attack slash or the tops and limbs of dead, dying, or suppressed trees. However, they are capable of attacking and killing apparently healthy sapling or pole-size pines.

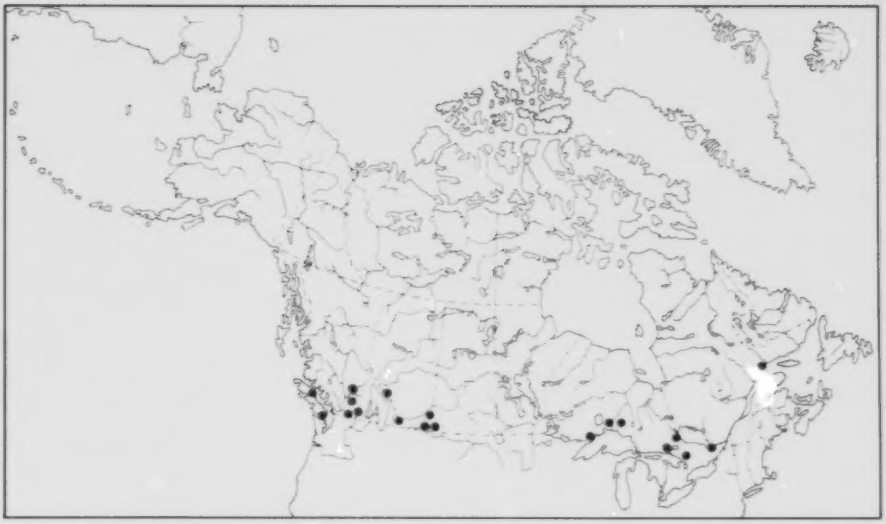
The gallery consists of a large central chamber from which two to five short, usually curved egg galleries radiate. Each egg gallery is 2–3 cm long and contains 16–23 egg niches. The larval galleries start in the inner bark, enter the cambium, and engrave the wood quite deeply. The pupal cells are almost entirely in the sapwood. The life history and number of generations per year are not known.



Figs. 42–47. Declivities of *Ips* spp. 42, *I. latidens;* 43, *I. mexicanus;* 44, *I. emarginatus;* 45, *I. pini;* 46, *I. plastographus;* 47, *I. perroti.*



Figs. 48–51. Declivities of *Ips* spp. 48, *I. borealis*; 49, *I. tridens*; 50, *I. calligraphus*; 51, *I. grandicollis*.



Map 75. Distribution of *Ips latidens*.

Ips concinnus (Mannerheim) (***hirsutus*** Eichhoff, ***chamberlini*** (Swaine) (Figs. 90 and 187)

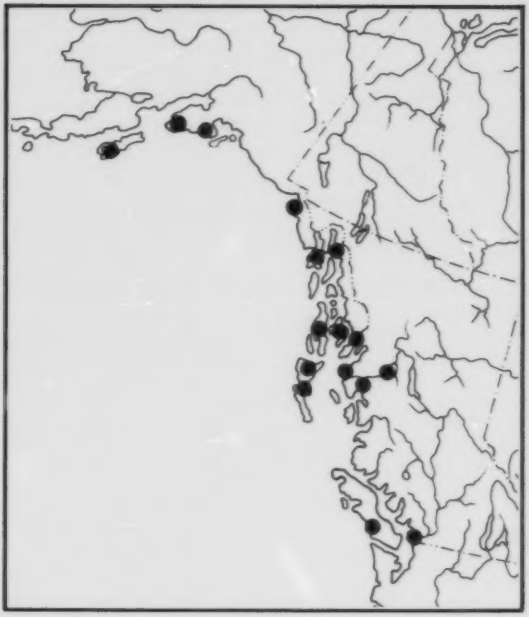
Diagnosis. Length 3.6–4.5 mm. Frons convex, moderately finely granulate, usually with a fine carina or a median tubercle above the epistomal margin; antennal club oval, sutures very strongly elongate-arcuate; elytral interspaces punctured and setose; declivity steep, lateral margins with three teeth, the lowest tooth longer, capitate to subacute at tip, the middle tooth about twice the size of the upper tooth.

Hosts. *Picea sitchensis*.

Distribution (Map 76). Southeastern Alaska, along the coast of British Columbia; coastal regions of Washington to northern California.

Biology. Bright and Stark (1973).

Little is known of the life history or habits of this species. The adults attack living, dying, or felled Sitka spruce, but apparently cause little mortality. The parent galleries are in the phloem-cambial region, engraving both bark and wood. From one to five short, crescent-shaped egg galleries radiate from the central nuptial chamber (Fig. 187). From two to five (usually four) eggs are placed in each egg niche, a characteristic that is unique to this species and *I. mexicanus*. Each egg niche is about 2 mm in diam and is constructed on the outer curve of the egg gallery.



Map 76. Distribution of *Ips concinnus*.

Ips mexicanus Hopkins (***radiatae*** Hopkins) (Fig. 43)

Diagnosis. Length 4.3–4.9 mm. Very similar to *I. concinnus*, in the previous description; distinguishable most easily by the characters given in the key and by the primary hosts.

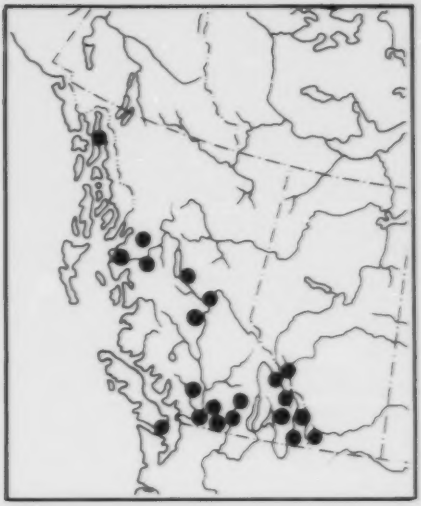
Hosts. Most species of *Pinus* in its range.

Distribution (Map 77). Southeastern Alaska and Western Canada; western United States to Guatemala.

Biology. Bright and Stark (1973), Struble (1961), and Trimble (1924).

Adults of this species usually attack weakened or dying trees, although they have killed young *Pinus radiata* in plantations in the United States.

Galleries are very similar to *I. concinnus*.



Map 77. Distribution of *Ips mexicanus*.

Ips emarginatus (LeConte) (Fig. 44)

Diagnosis. Length 4.5–6.3 mm. Frons convex, shallowly transversely impressed above epistoma, surface granulate-rugose, with a median tubercle (♂) or a short carina or granule (♀) above epistomal margin; sutures of antennal club moderately bisinuate and obtusely angled at the middle; elytral interspaces not punctured on disk; declivity steep, usually with three teeth on lateral margin, the lowest or third spine broad, compressed, and emarginate at the tip, the other two teeth smaller and acute to rounded at the tip.

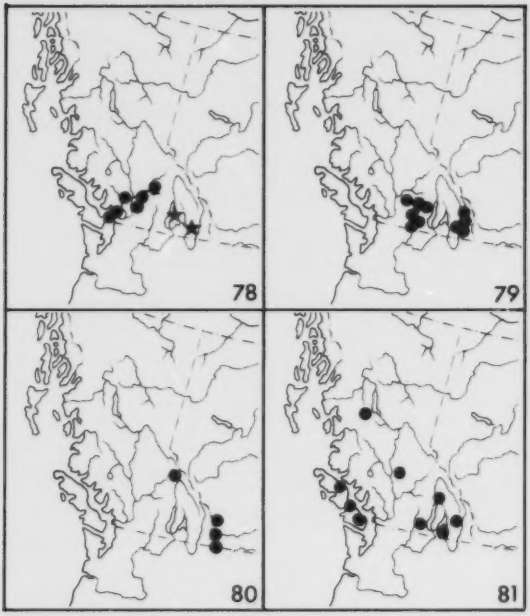
Hosts. *Pinus ponderosa* and *P. contorta*.

Distribution (Map 78). Southern British Columbia; western United States.

Biology. Bright and Stark (1973) and Keen (1952).

I. emarginatus is most often found in Canada attacking and killing trees in association with the mountain pine beetle, *D. ponderosae*, in ponderosa and lodgepole pine. It has also been reported that this species attacks and kills trees by itself.

The galleries of this species are characterized by the long, vertical, nearly parallel egg galleries up to 60 cm or more long, which run up and down the tree and connect at various points. Its work is often mistaken for that of the mountain pine beetle, but the galleries belonging to *I. emarginatus* are distinguishable by the absence of boring dust in the galleries and the presence of a large nuptial chamber.



Maps 78–81. Distribution of *Ips* spp. 78, *I. emarginatus* (●) and *I. plastographus* (★); 79, *I. integer*; 80, *I. woodi*; 81, *I. montanus*.

Eggs are laid singly in niches along the egg gallery, and the larvae develop close to the egg gallery. The pupal cells are large and close together, often touching. There are probably two generations a year in Canada.

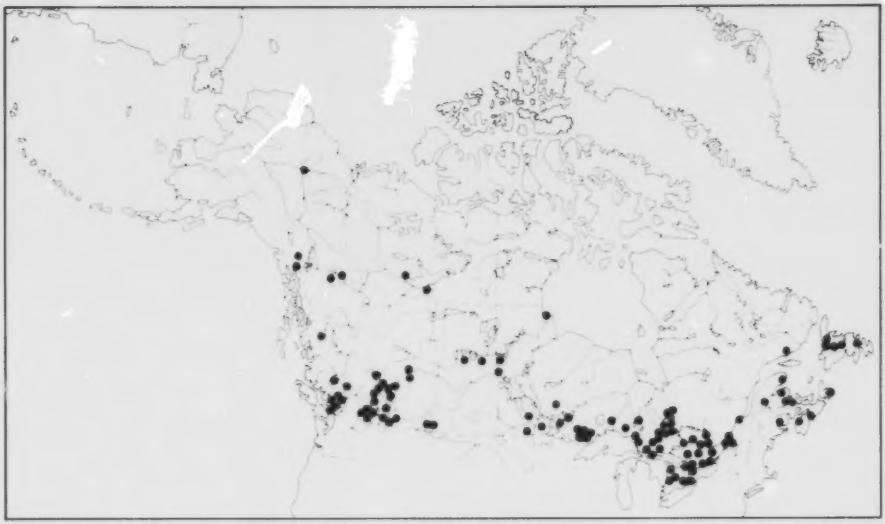
Ips pini (Say) (***dentatus*** Sturm, ***pallipes*** Sturm, ***praefrictus*** Eichhoff, ***oregonis*** Eichhoff, ***rectus*** LeConte, ***laticollis*** Swaine) (Figs. 45, 92, 132, 170, and 188)

Diagnosis. Length 3.5–4.2 mm. Frons convex, densely, coarsely punctate on vertex, granulate below, with a short, fine, longitudinal carina above epistoma (♀) or a median tubercle (♂); antennal club elongate-oval, sutures bisinuate and obtusely angled at middle (Fig. 92); elytral interspaces not punctate; declivity deeply excavated, lateral margins with four teeth, the third tooth larger than the others, capitate or subcapitate (♂) or similar to the second (♀) (Fig. 45).

Hosts. *Pinus* spp.; rarely *Picea* spp.

Distribution (Map 82). Transcontinental in Canada; eastern United States south to Tennessee and western United States into northern Mexico.

Biology. Reid (1955), Sartwell et al. (1971), and Thomas (1961).



Map 82. Distribution of *Ips pini*.

Adults of this species, commonly called the pine engraver, usually attack the thin-barked portions of slash, and dead or dying trees. They often develop such large numbers that they attack and kill trees up to 20 cm in diam and the tops of larger trees.

The gallery system consists of three or four egg galleries radiating from a central nuptial chamber, forming an X or Y pattern (Fig. 188). Eggs are laid singly in niches on both sides of the egg gallery; they hatch in about 10 days. The larvae mine at right angles to the egg gallery for about 3 cm. Pupation takes place at the end of the mine in a pupal cell constructed partly in the phloem and partly in the wood. Pupation lasts about 10 days.

There may be two generations a year in Canada.

Ips integer (Eichhoff) (Fig. 91)

Diagnosis. Length 4.5–6.2 mm. Frons convex, granulate, with a median tubercle connected to epistomal tubercle by a carina; antennal club elongate-oval, sutures acutely angled at center; elytral interspaces not punctured except on caudal half; elytral declivity deeply excavated, lateral margins with four spines, these spines acute to subacute, the third larger than the others, capitate (♂) or subacute (♀).

Hosts. *Pinus ponderosa.*

Distribution (Map 79). Southern interior of British Columbia; western North America to Guatemala.

Biology. Lanier (1970).

Adults of this species generally attack and breed in the thick-barked, large diameter portion of weakened or felled trees.

Males are joined by one to five females, who construct egg galleries to 50 cm long. Egg niches are contiguous and so plentiful that the gallery walls present a saw-toothed appearance.

Adults of *I. integer* may coexist and occasionally hybridize with *I. plastographus* where the populations of the two species meet.

Ips plastographus (LeConte) (Fig. 46)

Diagnosis. Length 4.0–5.5 mm. Closely resembles *I. integer*, differing only by the lack of an epistomal tubercle and carina and by the presence of the only moderately developed frontal tubercle.

Host. *Pinus contorta.*

Distribution (Map 78). Southern interior of British Columbia; southern California to Washington and in the northern Rocky Mountain states to northern Wyoming.

Biology. Lanier (1970).

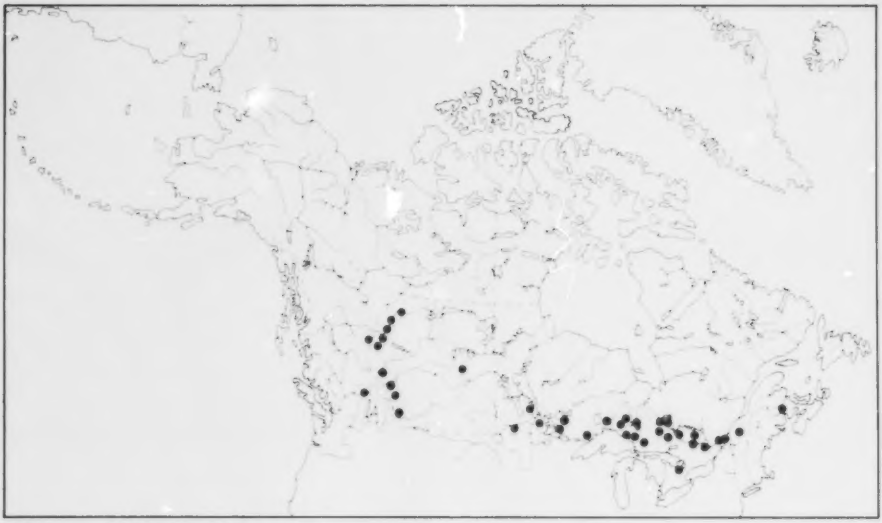
Adults of this species usually attack only the upper side of prostrate trees. From each nuptial chamber, two or three egg galleries extend 10–30 cm along the grain. Egg niches are closely placed, but not contiguous as in *I. integer*. Teneral adults deeply score the xylem and often bore holes 6–12 cm into the xylem. These holes apparently serve as refuges from predators or lethal high temperatures and may also be used as hibernation chambers.

Lanier described two subspecies of *I. plastographus* (1970). *I. plastographus plastographus*, a subalpine form, occurs in British Columbia. The other subspecies, *I. plastographus maritimus*, occurs along the coast of California.

Ips perroti Swaine (Figs. 47 and 93)

Diagnosis. Length 2.8–3.8 mm. Frons convex, finely granulate on surface, with the median tubercle placed nearly on the epistomal margin; antennal club slightly elongate-oval, sutures usually straight; elytral interspaces punctate; elytral declivity excavated, lateral margins with four teeth, the first tooth slightly curved and acute, the second and third acute or subacute (♀) or capitate (♂), the fourth subacute.

Hosts. *Pinus banksiana, P. contorta,* and *P. resinosa.*



Map 83. Distribution of *Ips perroti*.

Distribution (Map 83). New Brunswick to British Columbia; Michigan to Minnesota.

Biology. Reid (1955).

Adults of this species are usually found in slash or thin-barked portions of dead or dying trees.

The gallery patterns resemble those constructed by *I. pini*. Instead of moving away from the egg galleries, as in most species of *Ips*, the larvae of *I. perroti* enlarge pockets adjacent to the egg galleries and use these pockets for pupating.

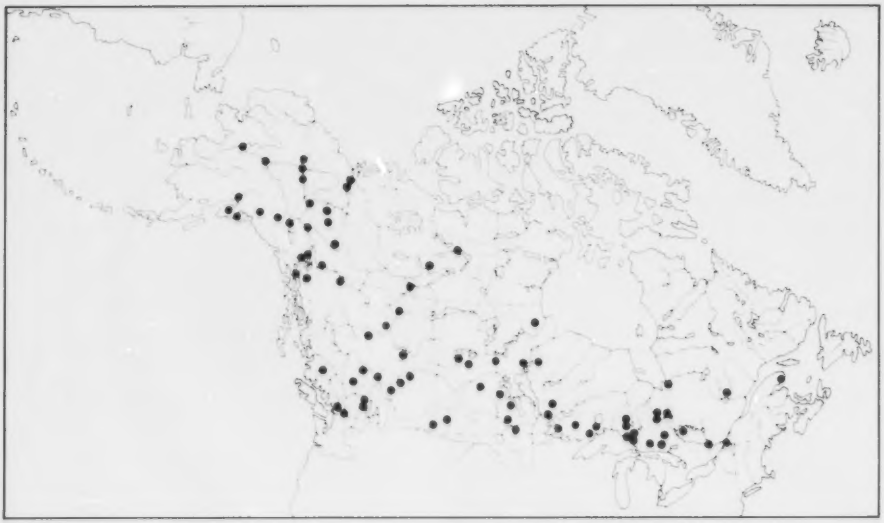
There is probably one generation a year in the northern locations.

Ips perturbatus (Eichhoff) (***hudsonicus*** LeConte, ***interpunctus*** Eichhoff)

Diagnosis. Length 4.2–4.8 mm. Frons evenly convex, granulate-punctate, with two granules or small tubercles arranged in a horizontal line midway between epistomal margin and upper level of eyes; antennal club elongate-oval, sutures bisinuate; elytral interspaces not punctured except on caudal one-quarter or half; elytral declivity excavated, lateral margins with four teeth, the third tooth larger than the others, conical, and acute at the tip.

Hosts. *Picea* spp.; also *Pinus banksiana* and *P. contorta*.

Distribution (Map 84). Transcontinental in Canada; northern United States.



Map 84. Distribution of *Ips perturbatus*.

Biology. Hopping (1965).

Galleries of this species are not particularly distinctive except that the egg galleries are wider than those of other species of *Ips* in Canada. The pattern closely resembles that of *I. pini*.

Ips woodi Thatcher

Diagnosis. Length 4.1–5.0 mm. Frons convex, densely granulate-punctate; antennal club elongate-oval, sutures bisinuate, the second suture more strongly bisinuate and subacutely angled at the middle; elytral interspaces punctate; elytral declivity excavated, lateral margins with four teeth, the third tooth larger than the others, strongly capitate, and acute or subacute at the tip.

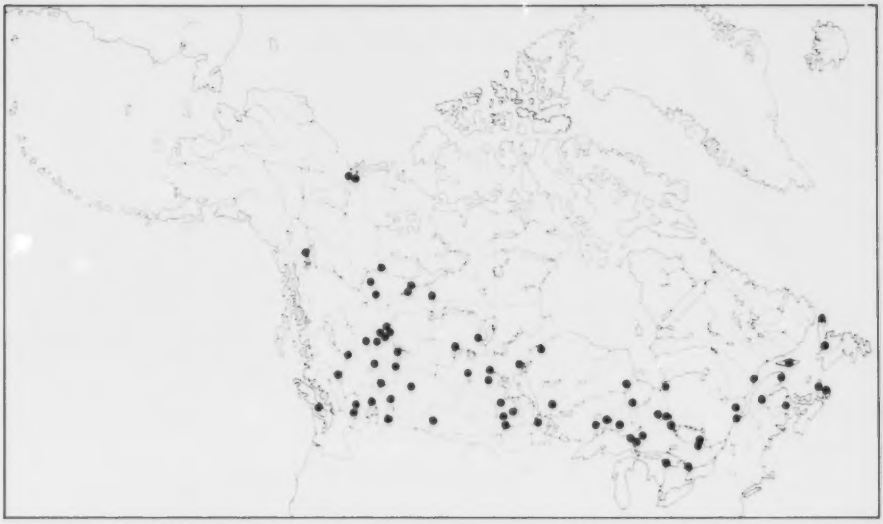
Host. *Pinus flexilis*.

Distribution (Map 80). Southern Alberta; Montana to Utah.

Biology. Not investigated.

Ips borealis Swaine (***swainei*** R. Hopping, ***thomasi*** G. Hopping) (Fig. 48)

Diagnosis. Length 3.0–3.6 mm. Frons convex to slightly elevated, smooth, pubescent or glabrous (♀) to coarsely punctate and sparsely granulate (♂); antennal club oval, sutures bisinuate, the second suture more strongly



Map 85. Distribution of *Ips borealis*.

bisinuate; elytral interspaces punctured; elytral declivity excavated, lateral margins with four teeth, the third tooth larger than the others, stouter, more cylindrical, subacute at the tip.

Hosts. *Picea* spp.

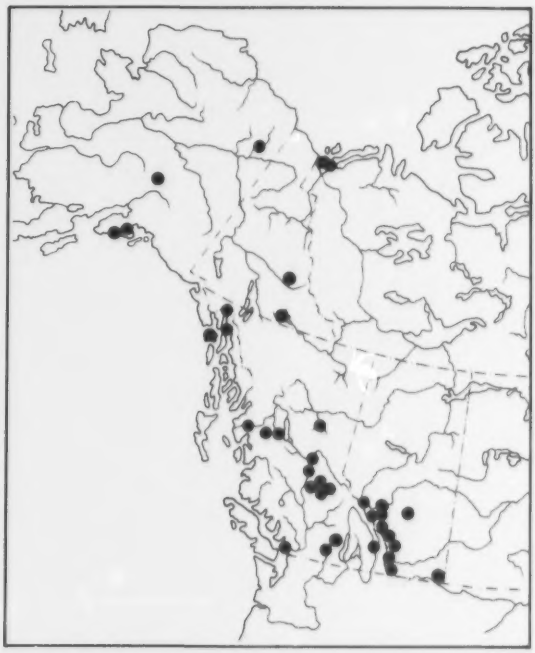
Distribution (Map 85). Transcontinental in Canada; northern United States.

Biology. Not investigated.

Ips tridens (Mannerheim) (***interruptus*** Mannerheim, ***engelmanni*** Swaine, ***yohoensis*** Swaine, ***dudius*** Swaine, ***semirostris*** Hopping, ***amiskiwiensis*** Hopping) (Figs. 49 and 94)

Diagnosis. Length 3.6–4.6 mm. Frons fairly to strongly protuberant on lower part, sometimes with a dense brush of long setae or a short pile or glabrous (♀) or surface evenly convex, coarsely granulate (♂); antennal club oval, sutures bisinuate; elytral interspaces punctate; elytral declivity excavated, lateral margins with four spines, the third spine larger than the others, capitate with an acute to subacute tip.

Hosts. *Picea* spp.



Map 86. Distribution of *Ips tridens*.

Distribution (Map 86). Western Canada and Alaska; northwestern United States.

Biology. Bright and Stark (1973).

This species is not economically important because its adults attack only weakened, windthrown, or felled trees.

Males attack first and are joined by four to six females after the nuptial chamber is completed. Egg galleries are constructed parallel to the grain; they usually appear as contiguous pairs, with only a thin septum of phloem between them. The larvae mine at right angles to the gallery for about 3 cm, then turn and continue with the grain. They pupate about 5 cm from the egg gallery. The teneral adults may feed in the inner bark for some time before emerging.

Along the west coast of Canada, Alaska, and the United States, two or more generations are completed annually; in the mountains, only one generation or less is completed annually.

Ips calligraphus (Germar) (***exesus*** Say, ***chloroticus*** DeJean, ***conformis*** DeJean, ***praemorsus*** Eichhoff, ***ponderosae*** (Swaine) (Fig. 50)

Diagnosis. Length 3.5–6.5 mm. Frons convex, granulate-setose with a median tubercle above the epistomal margin; antennal club oval, sutures bisinuate; elytral interspaces punctate; elytral declivity excavated, lateral margins with six spines, the third spine the largest, acute to subacute (♀) or notched on ventral side resembling a crochet hook (♂).

Hosts. *Pinus* spp.

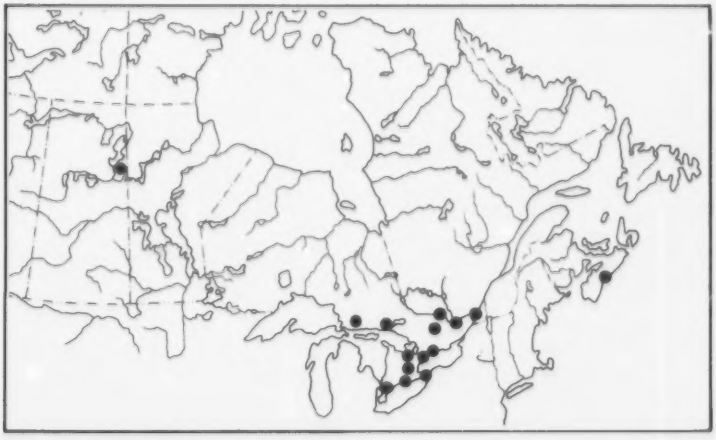
Distribution (Map 87). Southern Ontario, Quebec, and Nova Scotia; eastern United States and apparently introduced into California.

Biology. Baker (1972), Lanier (1972), Thatcher (1960), and Wood and Stark (1968).

This species is sometimes referred to as the coarse-writing engraver. Similar to the species whose descriptions follow, *I. calligraphus* attacks the stumps, trunks, and larger limbs of recently felled trees and is also capable of attacking and killing apparently healthy trees.

In California, new attacks have been observed during April. Subsequent generations emerged and attacked during late May, the middle of July, and early September. Activity has been observed as late as November and February. These observations indicate that four and possibly five generations are completed per year.

In the southeastern United States, a complete generation takes about 25 days. Therefore, the number of generations per year might be comparable to that reported from California.



Map 87. Distribution of *Ips calligraphus*.

Four to six egg galleries radiate from a large, centrally located nuptial chamber excavated by the male. The length of the egg galleries varies with the physical condition of the host plant and the environment, but usually they are 14–38 cm and deeply score the xylem, especially in thin-barked trees. Eggs are laid singly in niches, a characteristic of most species in this genus. Up to 100 eggs may be laid per female. Measurements of the head capsule indicate three larval instars.

Ips grandicollis (Eichhoff) (*cacographus* LeConte, *chagnoni* Swaine) (Fig. 51)

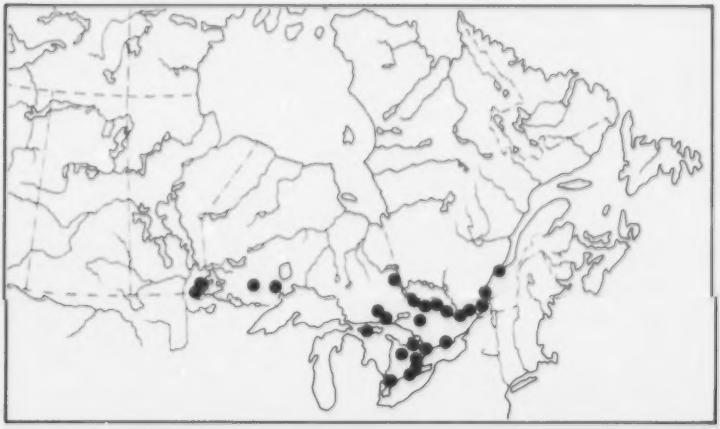
Diagnosis. Length 2.8–4.7 mm. Frons convex, granulate, with a small (♀) or prominent (♂) tubercle above the epistoma; antennal club oval, sutures bisinuate; elytral interspaces not punctured, at least on basal half; elytral declivity excavated, lateral margins with five spines, the third spine larger than the others, with a notch on the ventral side and a blunt tip.

Hosts. *Pinus* spp.

Distribution (Map 88). Eastern Canada; eastern United States and introduced into Australia.

Biology. Baker (1972), Beal and Massey (1945), Berisford and Franklin (1971), and Thatcher (1960).

Logging slash and damaged trees are the normal hosts of the southern pine engraver, *I. grandicollis*, but adults are capable of attacking and killing apparently healthy trees. Spot or group kills of young pole-sized pines are characteristic of this species, and during times of drought, these group kills increase in size and number.



Map 88. Distribution of *Ips grandicollis*.

Three to five egg galleries radiate from a central nuptial chamber; they groove both the wood and the inner bark. The larval mines are generally transverse.

Ips montanus (Eichhoff) (*vancouveri* Swaine)

Diagnosis. Length 4.7–5.5 mm. Frons convex, rather densely granulate, with a small median fovea; antennal club oval, sutures bisinuate; elytral interspaces punctate-setose; elytral declivity deeply excavated, lateral margins with five spines, the third spine larger than the others, with a notch on the ventral side and a blunt tip.

Host. *Pinus monticola.*

Distribution (Map 81). Southern British Columbia; northwestern United States south to California.

Biology. Bright and Stark (1973).

Very little is known of the biology of this species. *I. montanus* is typically associated with the mountain pine beetle, *D. ponderosae*, but it may attack slash and diseased or dying trees alone. Usually there are two or three egg galleries associated with each nuptial chamber and these form a tuning-fork pattern.

There are probably two generations per year. Some adults overwinter in large irregular shaped feeding aggregations in the bases of large western white pines.

Genus *Myeloborus* Blackman

Members of this genus are small beetles found in dead and dying twigs and small branches. They are of no economic importance.

The species in the genus are characterized by the stout body shape of the adults, the absence of chitinized septa at the lateral portions of the sutures of the antennal club, and the other characters given in the key to genera.

Blackman (1928*b*) gives a key to the species in the genus.

Key to the species of *Myeloborus* in Canada

1. Body 2.1–2.3 mm long; elytral declivity steep, strial punctures in striae 1 distinct but small ..... ***ramiperda* (Swaine)**

Body 2.5 mm or longer; elytral declivity oblique, strial punctures in striae 1 absent 2

2. Occurs in Eastern Canada; pronotum narrowly rounded anteriorly, posterior area deeply punctured; body about 2.6–2.7 mm long ..... ***fivazi*** **Blackman**

Occurs in southern British Columbia; pronotum broadly rounded anteriorly, posterior area granulate-punctate; body about 2.9 mm long ..... ***boycei*** **Swaine**

Myeloborus ramiperda (Swaine)

Diagnosis. Length 2.1–2.3 mm. Frons convex, closely, deeply punctured with a distinct longitudinal carina; sutures 1 and 2 of antennal club nearly straight; elytral declivity steep, weakly sulcate, the strial punctures distinct but small.

Host. *Pinus strobus.*

Distribution. Eastern Canada; northeastern United States west to Michigan.

Biology. Not investigated, probably similar to *M. fivazi.*

Myeloborus fivazi Blackman

Diagnosis. Length 2.6 mm. Frons convex, coarsely punctured, with a faint longitudinal carina; sutures 1 and 2 of antennal club weakly arcuate; elytral declivity sloping, shallowly sulcate, punctures of first striae obsolete.

Host. *Pinus resinosa.*

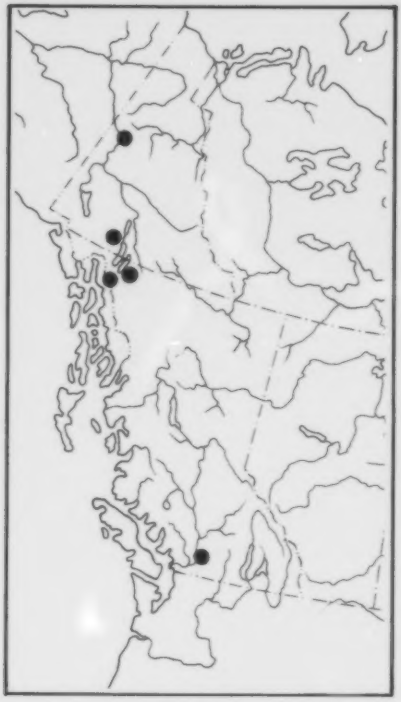
Distribution. Not recorded from Canada; known from northern New York and Michigan.

Biology. Blackman (1928*b*).

Adults of this species attack small twigs, entering among the needles on the underside. A small pitch tube is formed at the entrance hole. The entrance hole penetrates to the center of the twig, where it is enlarged to form a nuptial chamber. One or two egg galleries are constructed in the pith. Eggs are deposited in niches along the sides of the gallery and the larvae feed in the pith, wood, and inner bark. Pupation probably occurs in the pith. Evidence indicates that after the parent beetles have deposited their eggs in one twig, they may reemerge and make a second and third attack on different twigs.

Myeloborus boycei Swaine

Diagnosis. Length about 2.9 mm. Frons convex, moderately punctured, with a distinct longitudinal carina; sutures 1 and 2 of antennal club nearly straight; elytral declivity arched, shallowly sulcate, punctures of striae 1 obsolete.



Map 89. Distribution of *Myeloborus boycei*.

Host. *Pinus ponderosa* and *P. contorta*.

Distribution (Map 89). Western Canada; Oregon and California.

Biology. Not investigated.

Genus *Conophthorus* Hopkins

Members of this genus are usually found in pine cones and occasionally in pine twigs. Those species can cause heavy economic losses, especially in high-value commercial seed operations.

Adults of the various species enter the cone through its stem or side. They bore directly into the pith, where they lay their eggs (Fig. 189). When the cone is attacked, growth stops, although the infested cones may remain on the tree or fall to the ground. In either event, the infested cones are small and stunted. The larvae work away from the egg gallery and feed on the developing seeds and

other cone material. New adults remain in the cone over the winter and emerge in May or June. In northern areas, usually one generation a year is produced.

The specific characters of the species have not been determined. Most of the species described by Hopkins were based only on the species of host attacked and cannot be recognized by their own anatomical characters. Probably less than four species are represented in Canada. Biological studies must be completed before the various species can be recognized. Because of this gap in our knowledge, no reliable key can be constructed at this time.

Conophthorus banksianae McPherson

Length 2.4–2.7 mm.

Hosts. Cones of *Pinus banksiana*, *P. sylvestris*, and *P. resinosa*. Introduced *P. ponderosa* is also recorded as a host.

Distribution. Ontario; Michigan.

Biology. Herdy and Thomas (1961) and McPherson et al. (1970*a*, *b*).

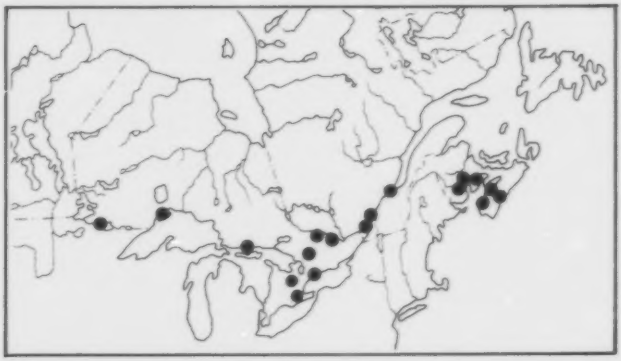
Adults attack shoot tips, rarely cones. The adults overwinter in fallen shoots and oviposit in new growth in the spring. The progeny complete their development by the end of September.

Conophthorus coniperda (Schwarz)

Length 2.7–3.3 mm.

Host. Cones of *Pinus strobus*.

Distribution (Map 90). Eastern Canada; eastern United States south to Virginia.



Map 90. Distribution of *Conophthorus coniperda*.

Biology. Odell and Goodwin (1964).

Adults of the white pine cone beetle, *C. coniperda*, overwinter mainly in the brood cones on the ground. In early spring, the adults emerge and attack the maturing second-year cones. First-year conelets and new shoots are attacked less often.

The females attack first. They bore into the cone at its junction with the petiole and effectively girdle and kill the cone. Infested cones drop to the ground within 6 weeks after the attack.

The egg gallery extends the full length of the cone axis. Eggs are deposited singly along the gallery. Larvae hatch in about 7 days and begin feeding on the seed embryo and the cone tissue. The larval period lasts about 4 weeks. Pupation takes place in a small frass-filled chamber at the end of the larval gallery.

This species is one of the most destructive pests associated with the loss of white pine seed in eastern North America.

Conophthorus contortae Hopkins

Length 3.1 mm.

Host. Cones of *Pinus contorta*.

Distribution. Not recorded from Canada but probably could occur along the coast of British Columbia; known along the coastal regions from California to Washington.

Biology. Keen (1958).

The seasonal history has not been determined. Adults are found in infested cones in October. Second-year cones are attacked in early spring, and the brood develops during the summer. Young adults overwinter in the cones and emerge the following spring. There is one generation a year.

Conophthorus flexilis Hopkins

Length 3.1 mm.

Host. Cones of *Pinus flexilis*.

Distribution. Not recorded from Canada but probably could occur in southern British Columbia and Alberta; known from the western United States throughout the range of the host tree.

Biology. Keen (1958).

Very similar to *C. contortae*.

Conophthorus monticolae Hopkins

Length 3–3.5 mm.

Host. *Pinus monticola.*

Distribution (Map 91). Southern British Columbia; northwestern United States.

Biology. Williamson et al. (1966).

Parent adults (usually the female only) enter the cone through the scales at the base. The female bores to the center of the cone, then turns and bores distally along the axis, constructing a straight gallery with laterally positioned egg niches spaced about 5 mm apart.

Each female lays about seven eggs. The larvae feed indiscriminately on the cone tissues and seeds. Cones wither and darken during the larval feeding period, but remain on the tree, eventually falling to the ground later in the year. Pupation takes place in the cone; the transformation to the adult stage takes about 1 week.

The winter is passed as mature adults in the aborted cones on the ground. In early spring, new cones are attacked. By fall, the brood has reached the adult stage, but these adults stay in the cones for another season. Thus, each generation takes 2 years to complete.

Conophthorus ponderosae Hopkins (Fig. 95)

Length 3.5–3.8 mm.

Host. Cones of *Pinus ponderosa.*

Distribution. Not recorded from Canada but probably could occur in southern British Columbia; known from the western United States.

Biology. Bright and Stark (1973) and Keen (1958).

In general, the biology of this species is similar to those species already described.

Adults attack second-year cones in the spring. They enter the cone by penetrating the scales close to the base. The adult female first bores completely around the stem of the cone, then distally through the central axis. This spiral gallery at the base of the cone cuts off the nourishment and kills the cone. Infested cones remain on the tree but they turn reddish brown and start to wither.

Conophthorus resinosae Hopkins (Figs. 134 and 172)

Length 2.7–3.2 mm.

Host. Cones of *Pinus resinosa;* rarely *P. banksiana.*

Distribution (Map 91). Eastern Canada; northeastern United States.

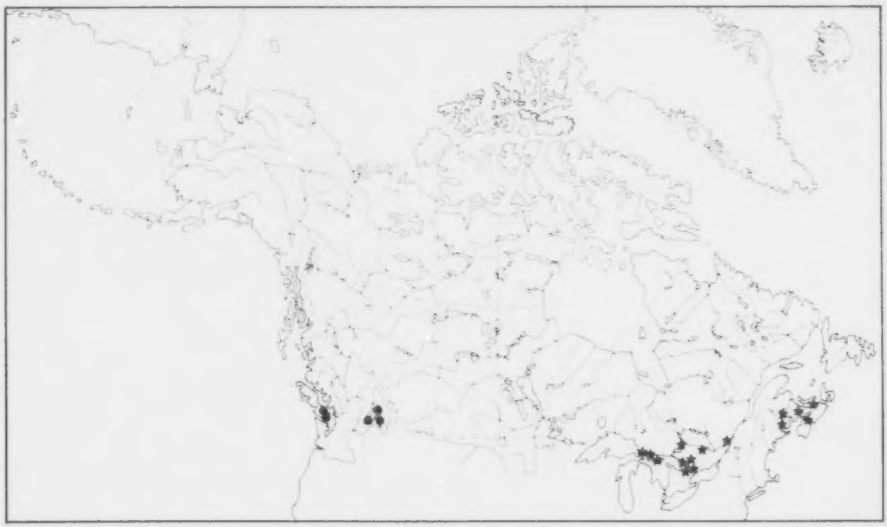
Biology. Lyons (1956) and McPherson et al. (1970*a*, *b*).

Damage by this species in Ontario is variable from year to year, but is often severe enough to make commercial seed collecting impossible or uneconomical.

Second-year cones of red pine are the preferred hosts of *C. resinosae*, but broods often develop in the current-year shoots and occasionally in second-year cones of jack pine. Activity in Ontario begins in May, when the beetles feed individually and do not mate or oviposit. Egg-laying attacks take place in late May. The female attacks first, penetrating close to the petiole on the underside of the cone. When the female reaches the center of the axis, she turns and bores toward the tip, constructing egg niches along the gallery. Up to 10 or 11 eggs are laid per cone and several cones may be attacked by a single female. After it has been attacked, the cone begins to wither and discolor, and eventually falls to the ground.

Larvae feed on cone seeds and scales, without tunneling in any particular direction. They pupate in the cone.

Apparently one generation per year and several broods per year are produced in Ontario.



Map 91. Distribution of *Conophthorus monticolae* (●) and *C. resinosae* (★).

Genus *Gnathotrichus* Eichhoff

The members of this genus are all ambrosia beetles. They construct their galleries in the bole of dying and dead trees, logs, stumps, and logging slash. The galleries consist of a tunnel extended through the bark into the wood with numerous lateral galleries parallel or almost parallel to the annual rings. The larvae are reared in short galleries called cradles, excavated above and below the lateral galleries. A fungus that provides food for the developing brood grows in the galleries. This fungus stains the galleries black. Successive generations may be reared in the same host material if there is enough moisture to maintain the fungus.

Members of *Gnathotrichus* are distinguishable by their elongate body shape (Figs. 135 and 173), the five-segmented antennal funicle (Figs. 96 and 97), the long curved setae on the outer borders of the antennal club and funicle of the female (Fig. 97), and the glabrous or nearly glabrous elytra.

The genus was revised by Blackman (1931*a*).

Key to the species of *Gnathotrichus* in Canada

1. Frons distinctly convergently aciculate, not punctured; fore tibiae with two submarginal teeth; pregula not produced ..... ***sulcatus*** **(LeConte)**

   Frons punctured at sides, not distinctly aciculate; fore tibiae with three submarginal teeth; pregula produced 2

2. Body less than 3.4 mm long; declivity feebly sulcate, interspace 3 weakly elevated if at all; central and eastern North America ..... ***materiarius*** **(Fitch)**

   Body more than 3.5 mm long; declivity deeply sulcate, interspace 3 distinctly elevated; western North America ..... ***retusus*** **(LeConte)**

Gnathotrichus sulcatus (LeConte) (Figs. 96 and 97)

Diagnosis. Length 3.5–3.9 mm. Frons convex, distinctly convergently aciculate; pregula not produced; sutures on antennal club strongly arcuate; elytral declivity convex, interspace 3 weakly to moderately elevated, bearing a row of small granules, strial punctures distinct.

Hosts. Probably all species of conifers in its range.

Distribution (Map 92). Southern British Columbia; western United States to southern Mexico.

Biology. Borden and Stokkink (1973), Daterman et al. (1965), Prebble and Graham (1957), and Rudinsky and Schneider (1969).

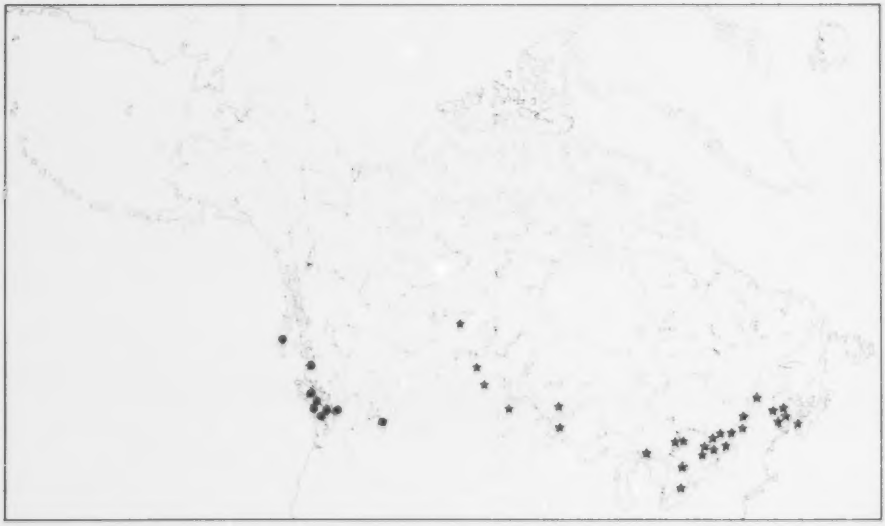
Adult activity begins between early April and late May, when temperatures reach 58–60°F (14–16°C). Attacks gradually reach a peak in late June or early July, then begin to taper off until late September, when a second peak occurs.

Daily activity depends on temperature and light intensity. A light intensity of about 100–200 ft-c (1075–2150 lx) seems optimal. A temperature of 58–60°F (14–16°C) is necessary to stimulate flight activity; a temperature above 70°F (21°C) inhibits activity. *G. sulcatus* and *G. retusus* are typical crepuscular flyers with a small number of individuals flying in the morning or at midday.

Galleries are begun by the male, but the female soon takes over this activity. A powerful aggregating pheromone is produced by the males when boring in host logs. The galleries are extended into the wood about 15–40 mm per week and excavation may continue for a year or more. The entire gallery system lies at one plane at right angles to the grain. Up to 60 eggs may be found in a single gallery system. The fungus is carried into the gallery by the males in specially modified body structures called mycangia, located in the forecoxal cavities (Ferris (1963)). Larvae and young adults feed on the fungus.

There is one generation per year in Canada.

This species causes heavy economic losses, particularly in the Pacific Northwest of United States. It may become even more important as forestry practices change.



Map 92. Distribution of *Gnathotrichus sulcatus* (●) and *G. materiarius* (★).

Gnathotrichus materiarius (Fitch) (Figs. 135 and 173)

Diagnosis. Length 2.9–3.2 mm. Frons convex, sometimes slightly flattened, distinctly punctured on sides, usually impunctate in center; pregula weakly produced; sutures of antennal club straight to weakly arcuate; elytral declivity convex, interspace 3 very weakly elevated, with about three small granules, strial punctures distinct.

Hosts. Probably all species of conifers in its range.

Distribution (Map 92). Northern Manitoba to Nova Scotia; eastern United States to Florida and Texas.

Biology. Beal and Massey (1945).

Very similar to that of *G. sulcatus*.

Gnathotrichus retusus (LeConte) (***alni*** Blackman)

Diagnosis. Length 3.4–4.0 mm. Frons convex, distinctly punctured on sides, weakly aciculate in center (♂) to smooth (♀); pregula produced; sutures on antennal club weakly arcuate; elytral declivity convex, deeply sulcate, interspace 3 strongly elevated on upper half, with three or four coarse granules, strial punctures usually obsolete.

Hosts. Probably all species of conifers in its range; also *Alnus* spp.

Distribution (Map 93). Southern British Columbia; western United States and probably into Mexico.

Biology. Chamberlin (1939) and Rudinsky and Schneider (1969).

Very similar to that of *G. sulcatus*.

Genus *Pseudopityophthorus* Swaine

Members of this genus are characterized by the dense brush of setae on the frons of the male, the irregularly punctured elytra, the subtransverse to strongly arcuate sutures of the antennal club (Fig. 98), and the hosts.

The galleries belonging to the species in this genus are constructed in various hardwood trees such as *Quercus, Castanea, Betula, Fagus, Carya*, and so on. They are of no economic importance except that *P. pruinosus* Eichhoff has been implicated as a possible vector of oak wilt. Occasionally, adults of various species cause concern when they appear in large numbers in homes in which oak firewood has been stored.

The genus was revised by Blackman (1931*b*).

Key to the species of *Pseudopityophthorus* in Canada

1. Body slender, three times or more longer than wide; frons of male not densely setose; declivital interspace 2 weakly flattened; sutures 1 and 2 of antennal club subtransverse ..... ***asperulus*** **LeConte**

   Body stouter, less than 2.8 times longer than wide; frons of male densely pubescent; declivital interspace 2 distinctly, often strongly impressed; sutures 1 and 2 of antennal club strongly arcuate, except in *minutissimus* 2

2. Body 1.5–1.8 mm long; sutures 1 and 2 of antennal club weakly arcuate ..... ***minutissimus*** **Zimmerman**

   Body longer than 1.8 mm; sutures 1 and 2 of antennal club strongly arcuate 3

3. Eastern; elytral pubescence short and stout; longer setae on declivital interspaces 1 and 3 scalelike; body shorter than 2.0 mm ..... ***pruinosus*** **Eichhoff**

   Western; elytral pubescence longer and more slender; longer setae on declivital interspaces 1 and 3 hairlike; body longer than 2.0 mm ..... ***pubipennis*** **LeConte**

Pseudopityophthorus asperulus (LeConte) (*gracilus* Blackman)

Diagnosis. Length 1.1–1.4 mm. Frons flattened, finely punctured, with fine, sparse, short setae, these setae shorter in female; sutures 1 and 2 of antennal club feebly arcuate, subtransverse; elytral striae with minute punctures in fairly definite rows; elytral declivity convex, interspace 2 very weakly flattened.

Hosts. *Quercus* spp., also recorded from *Betula* spp. and *Castanea dentata*.

Distribution. Not recorded from Canada but probably should occur in Quebec or New Brunswick; known in the eastern United States from Maine to Texas.

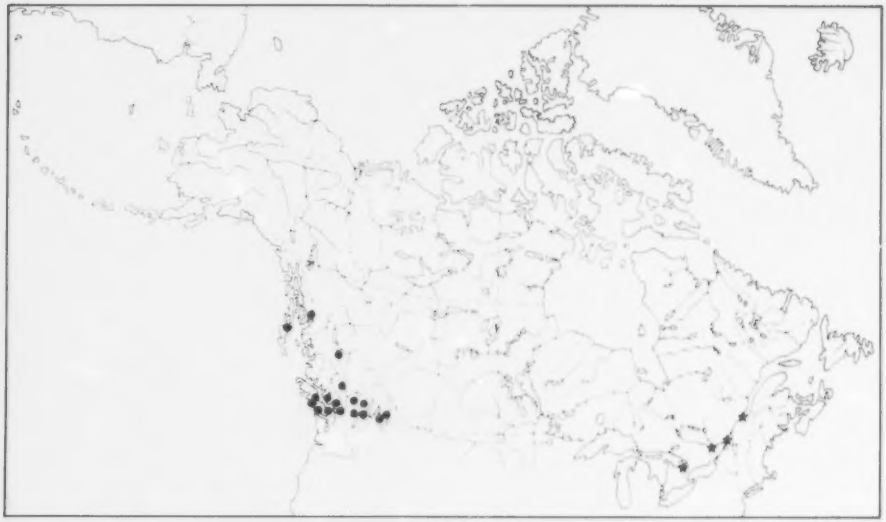
Biology. Not investigated.

Pseudopityophthorus minutissimus (Zimmerman) (Figs. 98, 136, and 174)

Diagnosis. Length 1.5–1.9 mm. Frons broadly flattened, finely and densely reticulate with long, coarse, incurved setae (♂) or densely punctured with very fine, yellowish setae of moderate length (♀); sutures 1 and 2 of antennal club subtransverse, weakly arcuate; elytral striae minutely punctured with no evidence of strial rows; elytral declivity convex, interspace 2 weakly flattened.

Hosts. *Quercus* spp., but probably could occur in most species of hardwoods in its range.

Distribution (Map 93). Southern Ontario and Quebec; eastern United States.



Map 93. Distribution of *Gnathotrichus retusus* (●) and *Pseudopityophthorus minutissimus* (★).

Biology. Chamberlin (1939).

Adults of this species attack recently cut trees, limbs, stumps, and cordwood. The entrance tunnel extends to the cambium, where two short tunnels are constructed. These are not egg galleries but are probably turning niches. Egg galleries extend from these short galleries to the left and right across the grain of the wood for about 2.5 cm, engraving the bark and the sapwood. The egg niches are quite prominent. The larval mines are straight, running with the grain of the wood and scoring both the bark and the wood.

In Canada there may be two or possibly three generations per year.

Pseudopityophthorus pruinosus (Eichhoff) (***querciperda*** Schwarz, ***pulvereus*** Blackman)

Diagnosis. Length 1.9 mm. Frons flattened, median area elevated, with a dense fringe of long, coarse, yellowish setae (♂) or convex, with short, slender, yellowish setae (♀); sutures 1 and 2 of antennal club strongly arcuate; entire elytral surface finely, densely punctured, strial rows not detectable; elytral declivity convex, distinctly impressed on each side of suture.

Hosts. Mainly *Quercus* spp., but also recorded from many other species of hardwood trees.

Distribution. Not recorded from Canada but probably should occur in Eastern Canada; known from eastern United States from Michigan and New York south to Texas and Florida.

Biology. Rexrode et al. (1965).

The habits are very similar to those of *P. minutissimus*. This species has been reported as a possible vector of oak wilt.

Pseudopityophthorus pubipennis **(LeConte) (Fig. 190)**

Diagnosis. Length 2.1–2.3 mm. Frons flattened, with a smooth, shining, median callus, and a dense fringe of long, coarse yellowish setae (♂) or frons not flattened, with short, fine setae except on a small shining area just above epistomal margin; sutures 1 and 2 on antennal club arcuate; elytral striae not punctured in rows, entire elytral surface finely, densely punctured; elytral declivity convex, slightly impressed on each side of suture.

Hosts. *Quercus* spp.

Distribution. Southern British Columbia; Washington to California.

Biology. Bright and Stark (1973).

The adult gallery has two branches that together are about 5 cm long and are transversely oriented (Fig. 190). The gallery is entirely in the inner bark and does not score the wood. The egg niches are in the soft parts of the bark. Larval mines are constructed in the inner bark and run with the grain for about 2.5 cm. Pupal cells are entirely in the inner bark.

Genus *Pityophthorus* Eichhoff

Members of *Pityophthorus* are distinguishable by the presence of chitinized septa at the lateral margins of the sutures of the antennal club (Fig. 99), their slender to moderately stout body, the distinctly asperate anterior portion of the pronotum, and the strongly sulcate elytral declivity. Species in this genus are closely related to those in *Myeloborus* and *Conophthorus*.

All species in this genus are found in dead or dying twigs or small branches. The gallery is usually star-shaped with three to five egg galleries radiating from a central nuptial chamber. Some species are found in the pith of twigs; these beetles construct a linear gallery similar to that constructed by species of *Myeloborus*. The biology of most species is not known.

Over 120 species of *Pityophthorus* have been described from the United States and Canada. At least 50 of these are known or suspected to occur in Canada and Alaska. Many of these are known only from a few specimens collected many years ago. Blackman (1928*b*) revised the genus.

There is no group of bark beetles in Canada that is harder to separate into the various species than this group. Because the group is so large and the species are so closely related, only a person with a great deal of experience can hope to distinguish them. The points of distinction are found mainly in the structure of

the frons and the elytral declivity. It is beyond the scope of this book to describe their minute differences. The species known or suspected to occur in Canada are given in the following list. The species have been divided into a western division (west of the 100th meridian) and an eastern division (east of the 100th meridian). Transcontinental species are given in both subdivisions.

Western species

Pityophthorus albertensis Blackman

Length 1.6 mm.

Hosts. *Pinus contorta, P. flexilis,* and *Picea glauca.*

Distribution. Alberta (Cypress Hills, Smith, and Banff) to the Yukon Territory; Alaska.

Pityophthorus alpinensis G. Hopping

Length 2.4–2.8 mm.

Host. *Larix lyallii.*

Distribution. Southern Alberta.

Pityophthorus aplanatus Schedl

Length 2.0 mm.

Host. *Pinus contorta.*

Distribution. Alberta and British Columbia.

Pityophthorus aquilonius Bright (probably a synonym of ***P. nitidus*** Swaine)

Length 1.9–2.6 mm.

Host. Unknown.

Distribution. Yukon Territory.

Pityophthorus borealis Swaine (***varians*** Schedl) (probably a synonym of ***P. nitidus*** Swaine)

Length 1.8–2.3 mm.

Host. *Picea glauca.*

Distribution. Northwest Territories and Alaska.

Pityophthorus collinus Bright

Length 2.4–2.8 mm.

Host. *Pinus albicaulis.*

Distribution. British Columbia.

Pityophthorus confertus Swaine (***burkei*** Blackman)

Length 1.9–2.6 mm.

Hosts. *Pinus* spp.

Distribution. Western Canada; western United States.

Pityophthorus confinis LeConte (Figs. 99, 137, and 175)

Length 2.5–2.8 mm.

Host. *Pinus ponderosa.*

Distribution. Southern British Columbia; western United States.

Pityophthorus cutleri Swaine

Length 2.0 mm.

Host. *Pinus ponderosa.*

Distribution. Southern British Columbia.

Pityophthorus demissus Blackman

Length 1.7 mm.

Host. *Abies lasiocarpa.*

Distribution. Not recorded from Canada but probably should occur in southern Alberta; known from northern Montana and Utah.

Pityophthorus fuscus Blackman

Length 2.0 mm.

Host. *Pinus contorta.*

Distribution. Not recorded from Canada but should occur in southern Alberta; known from northern Montana.

Pityophthorus gracilis Swaine

Length 2.2 mm.

Host. *Pinus contorta.*

Distribution. Not definitely recorded from Canada but should occur in Western Canada; known from western United States.

Pityophthorus grandis Blackman

Length 2.2–3.2 mm.

Host. *Pinus ponderosa.*

Distribution. Southern British Columbia; western United States.

Pityophthorus idoneus Blackman (***hopkinsi*** Blackman, ***ponderosae*** Blackman)

Length 1.6–2.0 mm.

Host. *Pinus ponderosa.*

Distribution. Southern British Columbia; western United States.

Pityophthorus intextus Swaine

Length 1.8 mm.

Hosts. *Picea glauca, Pinus banksiana,* and *Larix* spp.

Distribution. Alberta, British Columbia, Manitoba, and Saskatchewan.

Pityophthorus murrayanae Blackman (***elongatus*** Swaine, ***tenuis*** Swaine)

Length 2.2 mm.

Host. *Pinus contorta.*

Distribution. Southern British Columbia; western United States.

Pityophthorus nitidulus (Mannerheim) (***atratulus*** LeConte, ***puncticollis*** LeConte)

Length 2.4 mm.

Hosts. *Picea* spp., *Pinus* spp., and *Pseudotsuga menziesii.*

Distribution. Coastal British Columbia to Alaska; coastal northwestern United States.

Pityophthorus nitidus Swaine

Length 1.8–2.3 mm.

Hosts. *Picea* spp. and *Pinus* spp.

Distribution. Transcontinental.

Pityophthorus occidentalis Blackman

Length 2.4 mm.

Hosts. *Picea engelmanni*, and possibly *Abies lasiocarpa.*

Distribution. Interior British Columbia and Alberta; western United States.

Replaces *P. nitidulus* in interior mountain ranges.

Pityophthorus opimus Blackman (***aristatae*** Bright)

Length 2.2 mm.

Hosts. *Pinus contorta, P. flexilis*, and *P. albicaulis.*

Distribution. British Columbia to Saskatchewan; western United States.

Pityophthorus orarius Bright

Length 2.0–2.3 mm.

Host. *Pseudotsuga menziesii.*

Distribution. Coastal British Columbia.

Biology. Hedlin and Ruth (1970).

Pityophthorus pseudotsugae Swaine (Fig. 191)

Length 1.9–2.1 mm.

Hosts. *Abies* spp. and *Pseudotsuga menziesii.*

Distribution. Southern British Columbia and Alberta; western United States.

Pityophthorus smithi Schedl

Length 2.3 mm.

Host. *Pinus contorta.*

Distribution. Southern British Columbia.

Pityophthorus toralis Wood (***confusus*** Bright)

Length 2.1–2.4 mm.

Hosts. *Pinus flexilis, P. albicaulis,* and *P. contorta.*

Distribution. Southern Alberta and British Columbia; western United States.

Pityophthorus tuberculatus (Eichhoff) (***rugicollis*** Swaine, ***novellus*** Blackman)

Length 1.5–2.3 mm.

Hosts. All *Pinus* spp. in its range.

Distribution. Alberta and British Columbia; western United States.

Eastern species

Pityophthorus angustus Blackman

Length 1.9 mm.

Hosts. *Abies balsamea, Picea rubens,* and *Pinus strobus.*

Distribution. Not recorded from Canada but should occur in Eastern Canada; known from northern New York.

Pityophthorus balsameus Blackman

Length 1.9 mm.

Hosts. *Abies balsamea;* possibly *Picea* spp.

Distribution. Not recorded from Canada but should occur in Eastern Canada; known from Maine.

Pityophthorus biovalis Blackman

Length 2.0 mm.

Host. *Picea rubens.*

Distribution. Not recorded from Canada but should occur in Eastern Canada; known from Maine.

Pityophthorus briscoli Blackman

Length 2.0 mm.

Host. *Picea rubens.*

Distribution. Not recorded from Canada but should occur in Eastern Canada; known from Maine.

Pityophthorus carinicep*s** LeConte (canadensis*** Swaine)

Length 2.3–2.5 mm.

Hosts. *Pinus resinosa, P. strobus,* and *Abies balsamea.*

Distribution. Eastern Canada; northeastern United States.

Pityophthorus cascoensis Blackman

Length 1.8 mm.

Host. *Picea rubens.*

Distribution. Not recorded from Canada but should occur in Eastern Canada; known from Maine.

Pityophthorus concavus Blackman

Length 2.0 mm.

Hosts. *Picea* spp. and *Pinus resinosa.*

Distribution. Not recorded from Canada but should occur in Eastern Canada; known from Michigan to Maine.

Pityophthorus consimilis LeConte (***granulatus*** Swaine)

Length 1.6 mm.

Hosts. *Picea* spp., *Pinus* spp., and *Abies balsamea.*

Distribution. Manitoba to Nova Scotia; eastern United States.

Pityophthorus dentifrons Blackman

Length 2.1–2.3 mm.

Host. *Picea rubens.*

Distribution. Not recorded from Canada but should occur in Eastern Canada; known from New York to Maine south to North Carolina.

Pityophthorus intextus Swaine (see page 182)

Pityophthorus mundus Blackman (probably a synonym of ***P. consimilis*** LeConte)

Length 1.8 mm.

Hosts. *Picea* spp. and *Pinus* spp.

Distribution. Ontario and Quebec; eastern United States.

Pityophthorus nitidus Swaine (see page 183)

Pityophthorus opaculus LeConte (***pygmaeus*** Schedl)

Length 1.3–1.6 mm.

Hosts. *Picea* spp., *Pinus* spp., and *Abies balsamea*.

Distribution. Eastern Canada; eastern United States.

Pityophthorus patchi Blackman

Length 2.0 mm.

Hosts. *Picea* spp., *Pinus* spp., and *Abies balsamea*.

Distribution. Ontario and New Brunswick; northeastern United States.

Pityophthorus puberulus LeConte (***infans*** Eichhoff)

Length 1.4–1.6 mm.

Hosts. *Picea* spp., *Pinus* spp., and *Abies balsamea*.

Distribution. Eastern Canada; eastern United States.

Pityophthorus pulchellus Eichhoff (***hirticips*** LeConte, ***pusio*** LeConte)

Length 2.0 mm.

Hosts. *Picea* spp., *Pinus* spp., and *Abies balsamea*.

Distribution. Eastern Canada; eastern United States.

Pityophthorus pulicarius (Zimmerman)

Length 1.3–2.0 mm.

Hosts. All *Pinus* spp. in its range.

Distribution. Ontario and Quebec; eastern United States.

Pityophthorus rhois Swaine

Length 1.6 mm.

Hosts. *Rhus* spp. and *Acer saccharinum*.

Distribution. Eastern Canada; northeastern United States.

Pityophthorus shepardi Blackman

Length 1.5–1.8 mm.

Hosts. *Picea glauca* and *P. rubens*.

Distribution. Eastern Canada; northeastern United States.

Pityophthorus tonsus Blackman

Length 1.7 mm.

Hosts. *Picea* spp. and *Pinus resinosa*.

Distribution. Not recorded from Canada but should occur in Eastern Canada; known from Michigan to New Hampshire.

Pityophthorus watsoni Schedl

Length 2.2 mm.

Hosts. *Picea glauca* and *P. rubens*.

Distribution. New Brunswick to Ontario.

Genus *Monarthrum* Kirsch

Members of this genus are distinguishable by their slender body shape (Figs. 138 and 176), the two-segmented antennal funicle (Fig. 100), and the emarginate apex of the elytra.

The galleries extend deep into the wood. An ambrosial fungus stains the wood black around the gallery. These discolored pinholes can reduce the value of lumber taken from infested trees.

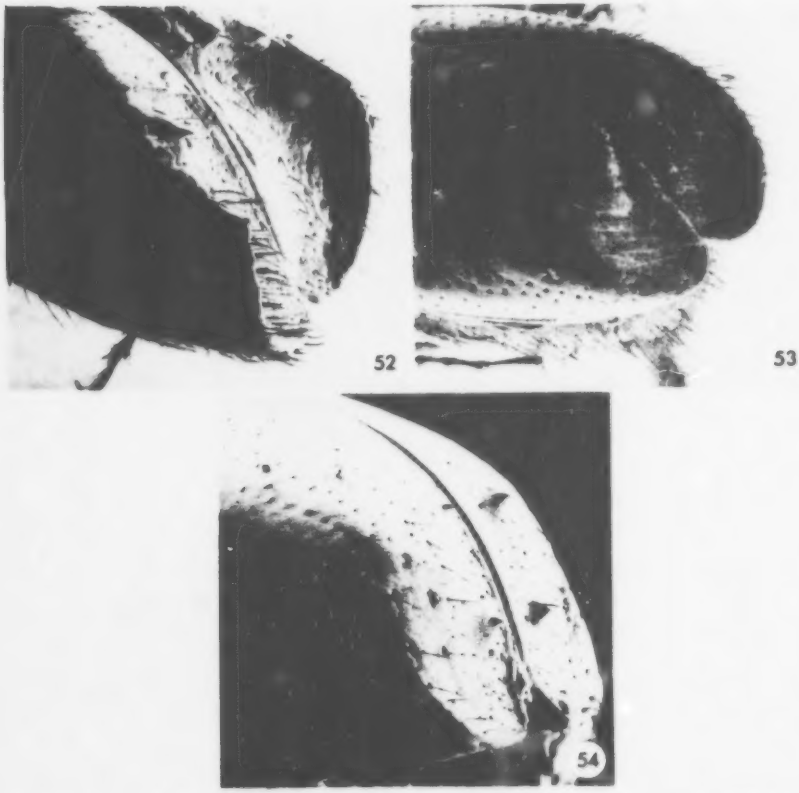
Key to the species of *Monarthrum* in Canada

1. Body large, over 3.5 mm long; frons with a prominent well-developed, submarginal epistomal process, broad in the male, narrow and bifid in the female; elytral declivity of the male deeply concave (Fig. 52) and of the female convex ..... ***scutellare*** **(LeConte)**

   Body smaller, less than 3.0 mm long; frons without a prominent, well-developed epistomal process; elytral declivity flattened in both sexes 2

2. Elytra pale yellow, the apex brown to black; elytral declivity with one small tubercle (Fig. 53) ..... ***fasciatum*** **(Say)**

   Elytra light to dark brown over entire surface; elytral declivity with two widely separated tubercles (Fig. 54) ..... ***mali*** **(Fitch)**



Figs. 52–54. Declivities of *Monarthrum* spp. 52, *M. scutellare* ♂; 53, *M. fasciatum*; 54, *M. mali*.

Monarthrum scutellare (LeConte) (***cavus*** LeConte, ***obliquecaudatum*** Schedl) (Figs. 52 and 192)

Diagnosis. Length 3.5–4.1 mm. Frons convex, densely punctured, with a prominent, submarginal epistomal process, this broad (♂) to narrow and bifid (♀); elytral declivity deeply concave with sharply elevated lateral margins (♂) to flattened with rounded lateral margins (♀).

Hosts. *Quercus* spp.

Distribution (Map 94). Southern British Columbia; Washington to central California.

Biology. Bright and Stark (1973).

Adults of this species attack dying, weakened, diseased, or recently dead trees or parts of trees.

Attack is initiated by the male by boring into the sapwood about 6 cm deep and there excavating a nuptial chamber. The female joins the male in the nuptial chamber and introduces the symbiotic fungus *Monilia brunnea* Verrall, which is transported in an enlargement of the forecoxal cavities of the female.

The female, assisted by the male, excavates two to four diverging galleries deep into the sapwood; each gallery is 5–15 cm long. In the side walls of the gallery, the female excavates egg niches, which are later extended into larval cradles by the larvae. The fungus becomes established in the vicinity of the egg

Map 94. Distribution of *Monarthrum scutellare* (●), *M. fasciatum* (★), and *M. mali* (○).

niches and it provides a source of food. Larval development takes 6–8 weeks, and pupation takes 2–3 weeks.

The number of generations per year in Canada is not known but there are two a year in California.

Monarthrum fasciatum (Say) (*gracilis* Eichhoff, *simile* Eichhoff) (Figs. 53 and 100)

Diagnosis. Length 2.5–3.0 mm. Frons convex, finely, densely punctate-granulate, opaque; elytral declivity steep in both sexes, with one small tubercle, surface densely pubescent (♂) or very sparsely pubescent (♀).

Hosts. *Fagus* spp., *Carya* spp., and *Quercus* spp. Probably occurs in most species of broadleaf trees in its range.

Distribution (Map 94). Southern Ontario and Quebec; eastern United States to Florida.

Biology. Chamberlin (1939).

The habits are very similar to *M. scutellare* (see page 190).

Monarthrum mali (Fitch) (*longulum* Eichhoff) (Figs. 54, 138, and 176)

Diagnosis. Length 2.2–3.0 mm. Very similar to *M. fasciatum* except for characters given in the key.

Hosts. *Acer* spp., *Betula* spp., *Quercus* spp., and *Ulmus* spp. Probably occurs in most species of broadleaf trees in its range.

Distribution (Map 94). Southern Ontario to New Brunswick; eastern United States south to Florida.

Biology. Chamberlin (1939).

The habits are very similar to *M. scutellare* (see page 190).

Genus *Corthylus* Erichson

Members of *Corthylus* are distinguishable by their stout body shape (Figs. 139 and 177) and one-segmented antennal funicle (Fig. 101).

The species in *Corthylus*, similar to the species in *Monarthrum*, construct their galleries deep in the sapwood of their host plant and there they feed on an ambrosial fungus. The fungal growth stains the wood, and the resulting defects cause serious downgrading of the lumber, which restricts the use of some hardwood species.

Key to the species of *Corthylus* in Canada

1. Tibiae of middle and hind legs with three teeth near tip; elytral declivity without tubercles ..... ***punctatissimus*** **Zimmerman**

   Tibiae of middle and hind legs with four teeth near tip; elytral declivity with small but distinct tubercles ..... ***columbianus*** **Hopkins**

Corthylus punctatissimus Zimmerman (Figs. 101, 139, and 177)

Diagnosis. Length 3.5–4.0 mm. Frons concave and distinctly pubescent (♀) to convex, transversely impressed above epistoma and glabrous (♂); antennal club very large, with two nearly straight sutures; elytra densely, irregularly punctured; elytral declivity convex, without tubercles or granules.

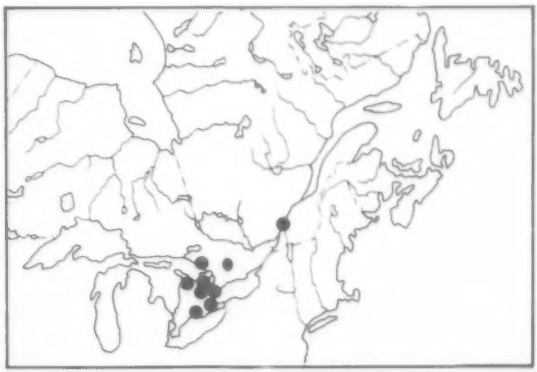
Hosts. Wide range of species of broadleaf trees.

Distribution (Map 95). Southern Ontario and Quebec; northeastern United States west to Minnesota.

Biology. Finnegan (1967).

Adults of this species attack material less than 2.5 cm in diam. The entrance hole is made at or near ground level, and the gallery penetrates into the sapwood then starts to spiral downward. The larvae develop in short chambers, 5–6 mm long, which project at right angles from the main gallery. The galleries are stained black by the ambrosial fungus. There is one generation per year.

During 1959 and 1960 high populations of this species resulted in mortality of sugar maple reproduction in Ontario.



Map 95. Distribution of *Corthylus punctatissimus*.

Corthylus columbianus Hopkins

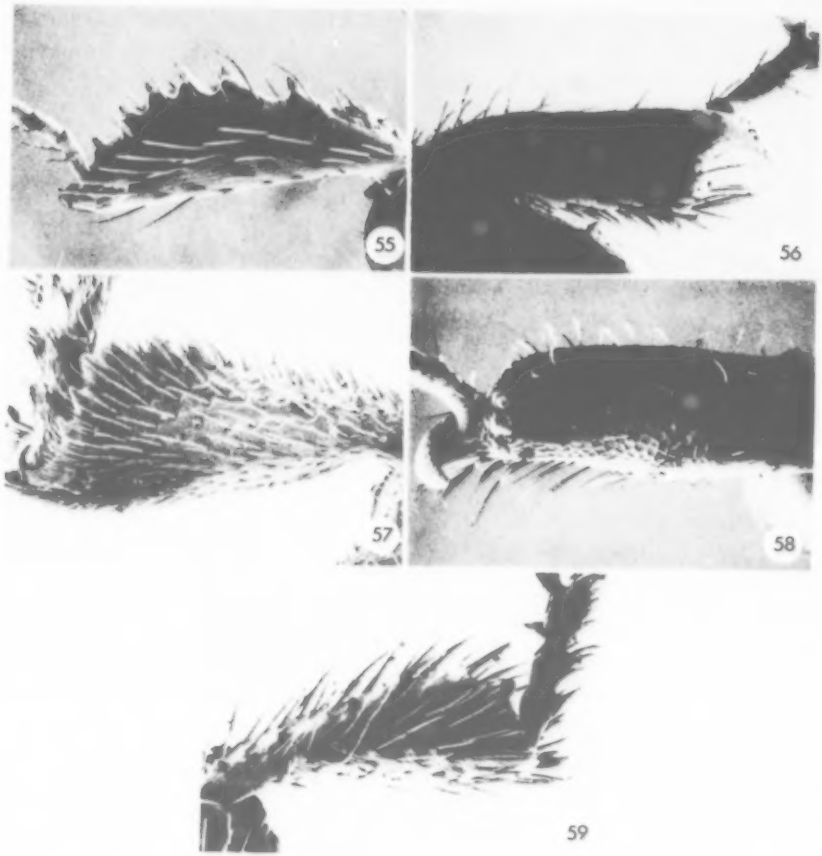
Diagnosis. Length 3.5–4.0 mm. Very similar to *C. punctatissimus*, but the two species can be distinguished by the characters given in the key.

Hosts. Wide range of species of broadleaf trees.

Distribution. Not recorded from Canada but should occur in Eastern Canada; known from eastern United States from Michigan and Massachusetts south to Arkansas and North Carolina.

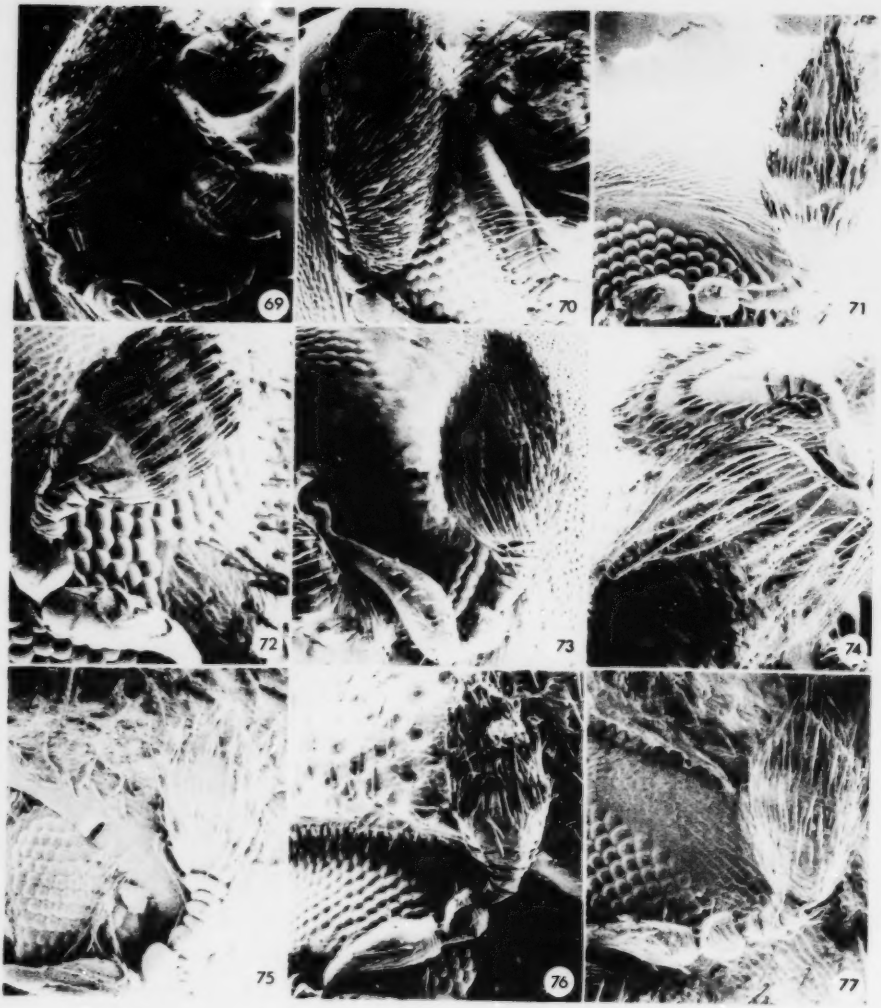
Biology. Kabir and Giese (1966), Milne and Giese (1969), Nord and McManus (1972), and White and Giese (1968).

Adults of this species construct galleries only in healthy sapwood. The galleries nearly always extend in a horizontal plane and usually are branched. The main gallery is constructed first, and it usually penetrates deeper than any of its branches; galleries usually have two or three branches. Short side galleries, 5–6 mm long, are constructed at right angles to the main galleries. These serve as egg cradles, and the immature stages remain in them from eclosion through pupation.

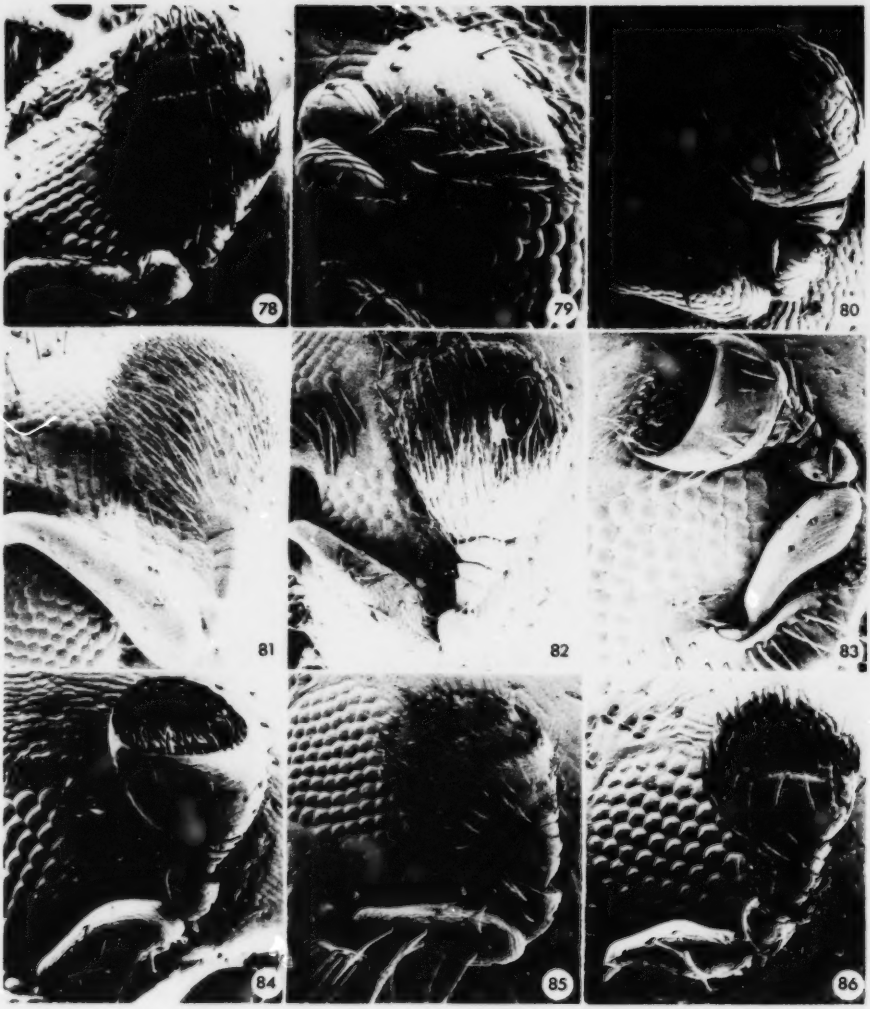


Figs. 55–59. Tibiae of various species. 55, *Xyleborus affinus*. 56, *Scolytus tsugae*. 57, *Hylurgops rugipennis*. 58, *Micracis swainei*. 59, *Orthotomicus caelatus*.

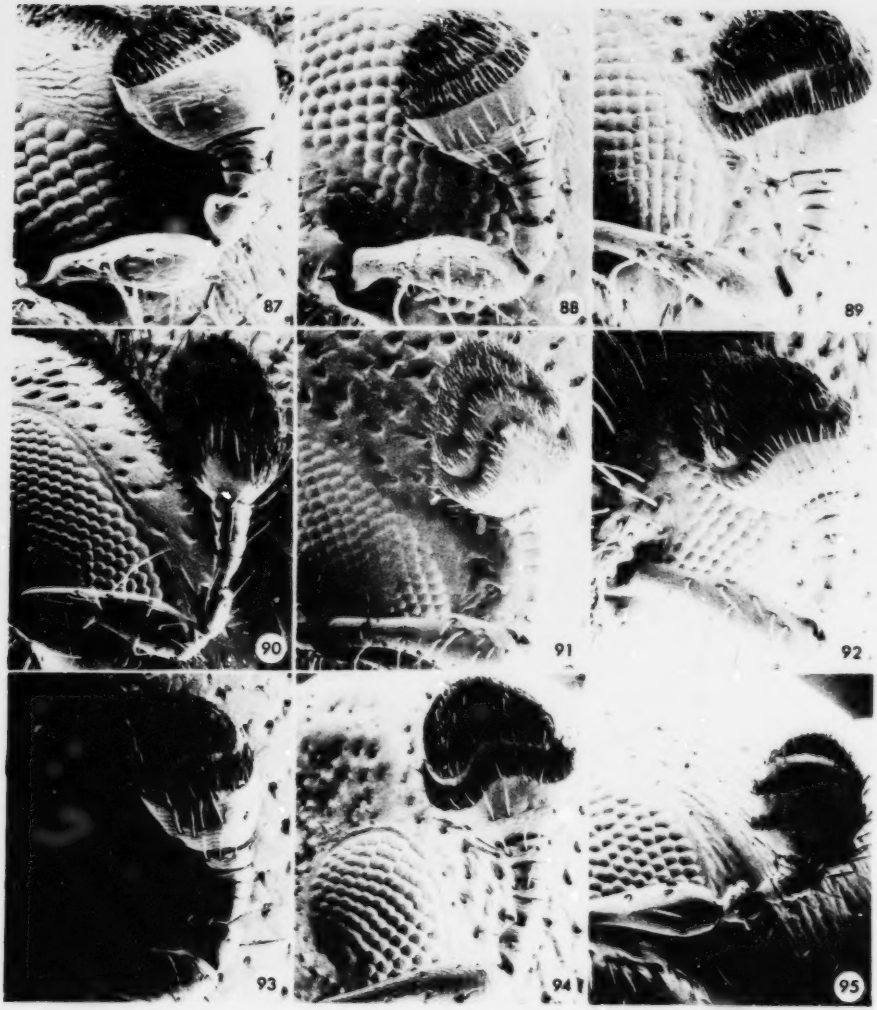
Figs. 60–68. Antennae of various species. 60, *Scolytus ventralis*; 61, *Hylastinus obscurus*; 62, *Hylastes macer*; 63, *Dendroctonus ponderosae*; 64, *Hylurgopinus rufipes*; 65, *Xylechinus montanus*; 66, *Alniphagus aspericollis*; 67, *Phloeosinus punctatus*; 68, *Leperisinus aculeatus*.



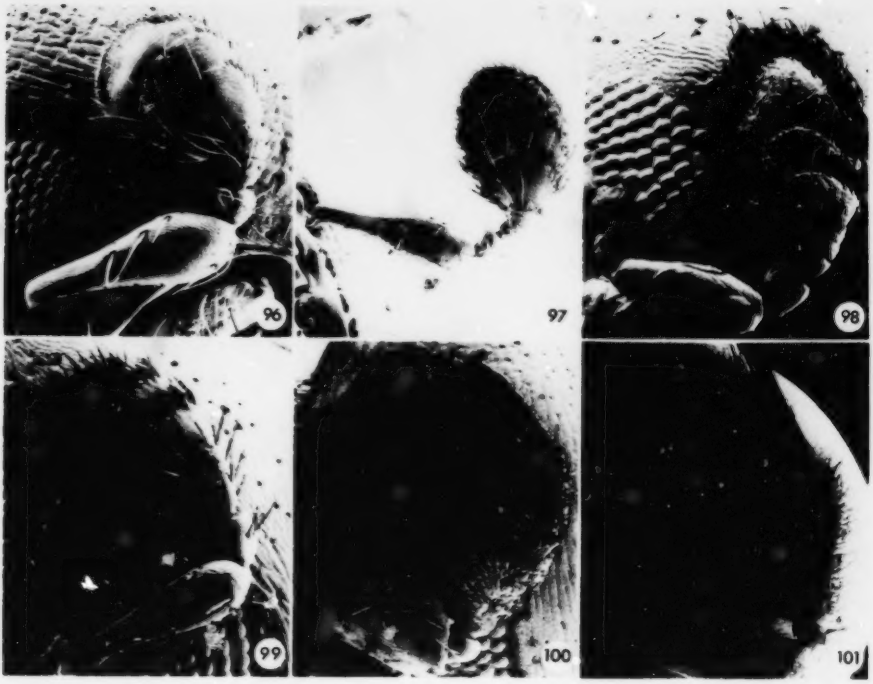
Figs. 69–77. Antennae of various species. 69, *Phloeotribus liminaris*; 70, *Chramesus hicoriae*; 71, *Chaetophloeus heterodoxus*; 72, *Carphoborus ponderosae*; 73, *Polygraphus rufipennis*; 74, *Micracis swainei*; 75, *Pseudothysanoes rigidus*; 76, *Trypophloeus striatulus*; 77, *Procryphalus utahensis*.



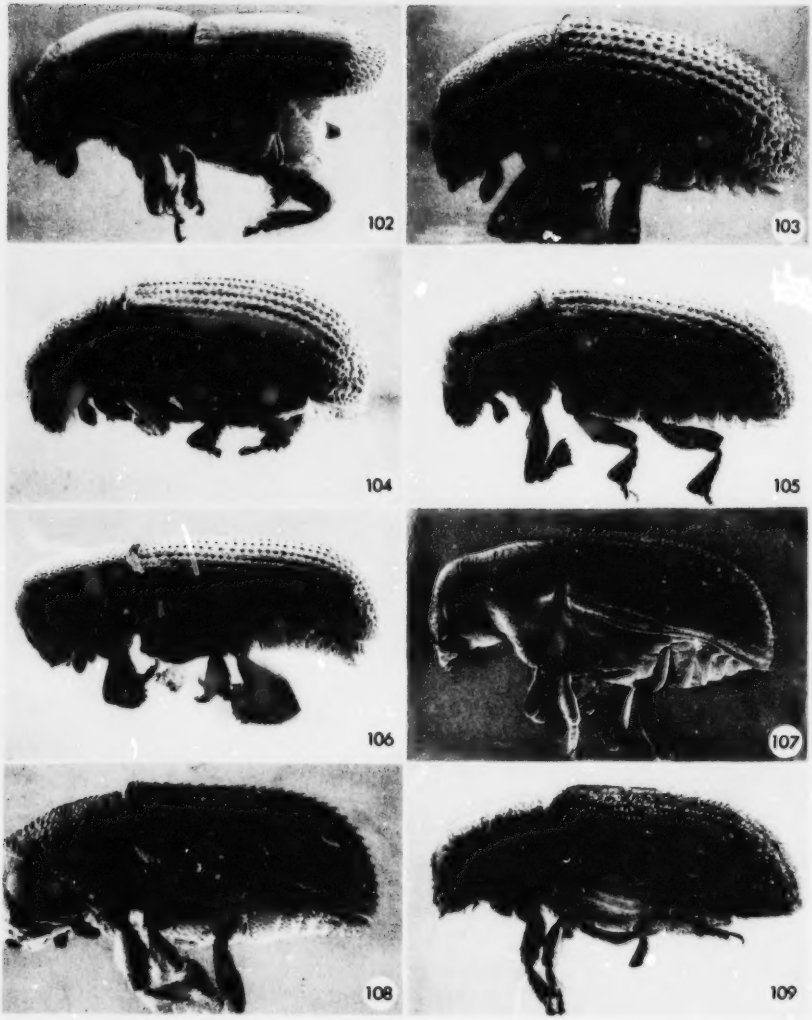
Figs. 78–86. Antennae of various species. 78, *Cryphalus ruficollis*; 79, *Crypturgus borealis*; 80, *Dolurgus pumilus*; 81, *Trypodendron lineatum*; 82, *Xyloterinus politus*; 83, *Dryocoetes affaber*; 84, *Xyleborus saxeseni*; 85, *Pityogenes plagiatus knechteli*; 86, *Orthotomides lasiocarpa*.



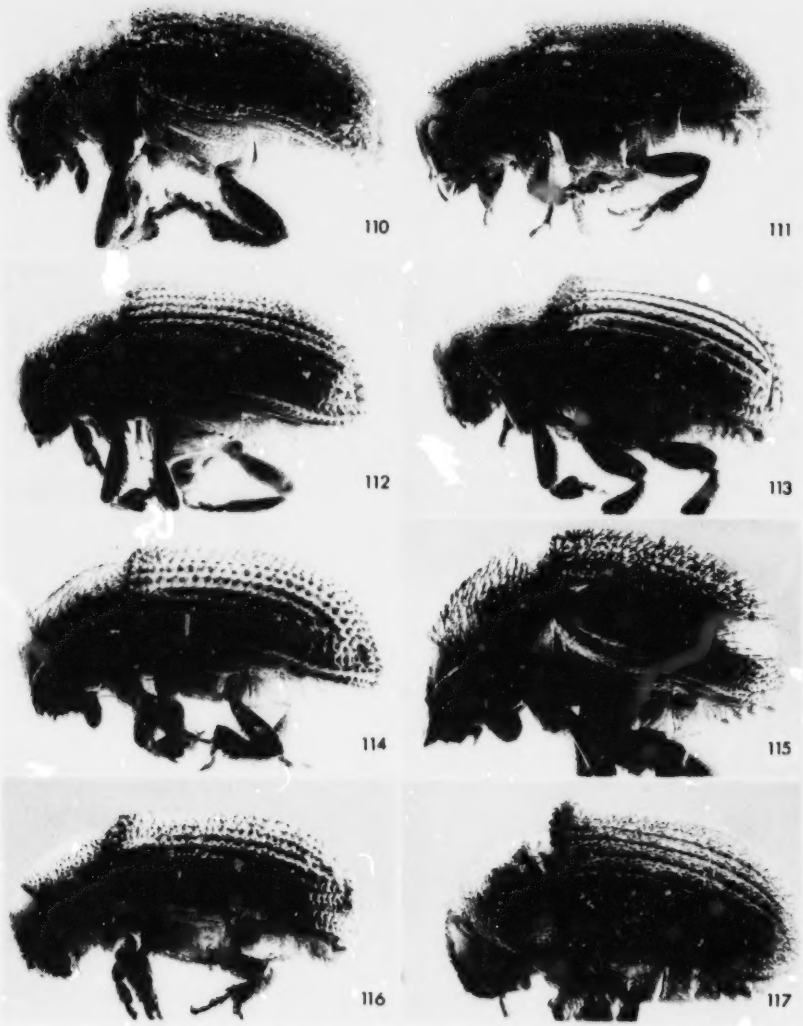
Figs. 87–95. Antennae of various species. 87, *Pityokteines minutus;* 88, *Orthotomicus caelatus;* 89, *Ips latidens;* 90, *I. concinnus;* 91, *I. integer;* 92, *I. pini;* 93, *I. perroti;* 94, *I. tridens;* 95, *Conophthorus ponderosae.*



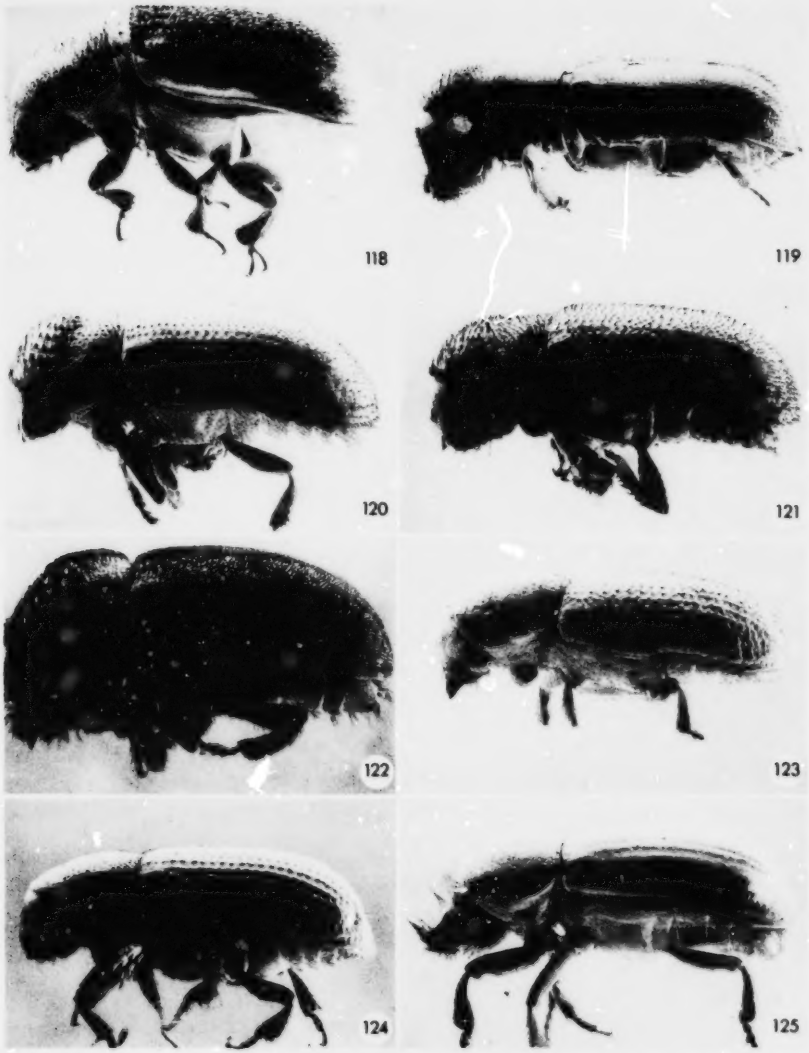
Figs. 96–101. Antennae of various species. 96, *Gnathotrichus sulcatus* ♂; 97, *G. sulcatus* ♀; 98, *Pseudopityophthorus minutissimus*; 99, *Pityophthorus confinis*; 100, *Monarthrum fasciatum*; 101, *Corthylus punctatissimus*.



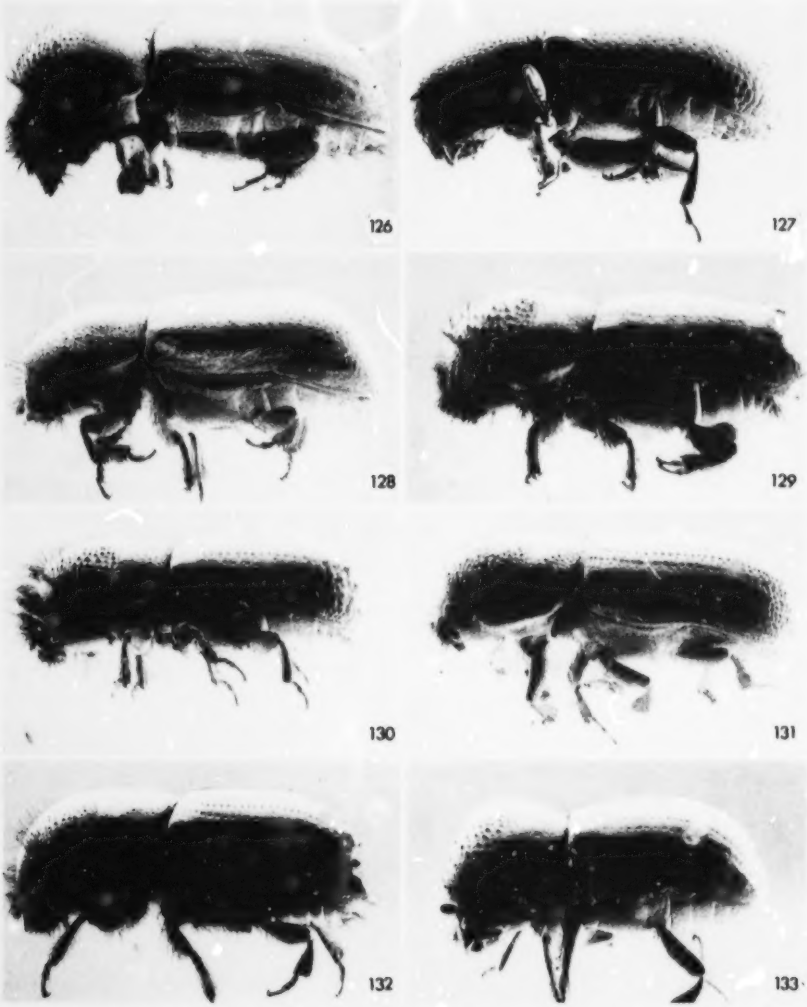
Figs. 102–109. Lateral views of various species. 102, *Scolytus piceae;* 103, *Hylastinus obscurus;* 104, *Scierus annectans;* 105, *Hylurgops rugipennis;* 106, *Hylastes macer;* 107, *Dendroctonus ponderosae;* 108, *Hylurgopinus rufipes;* 109, *Xylechinus montanus.*



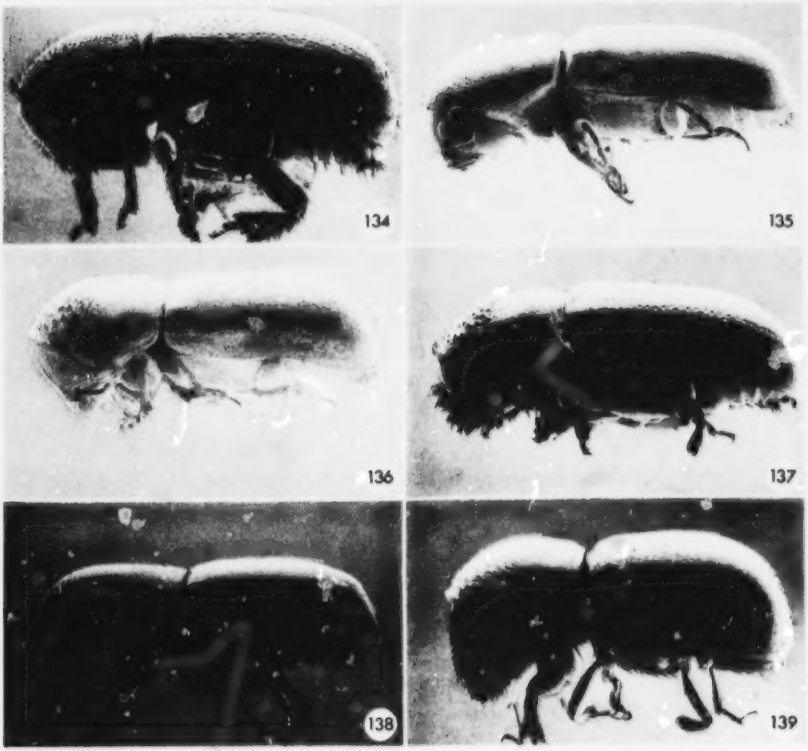
Figs. 110–117. Lateral views of various species. 110, *Pseudohylesinus grandis*; 111, *Leperisinus aculeatus*; 112, *Alniphagus aspericollis*; 113, *Phloeosinus punctatus*; 114, *Phloeotribus piceae*; 115, *Chramesus hicoriae*; 116, *Carphoborus carri*; 117, *Chaetophloeus heterodoxus*.



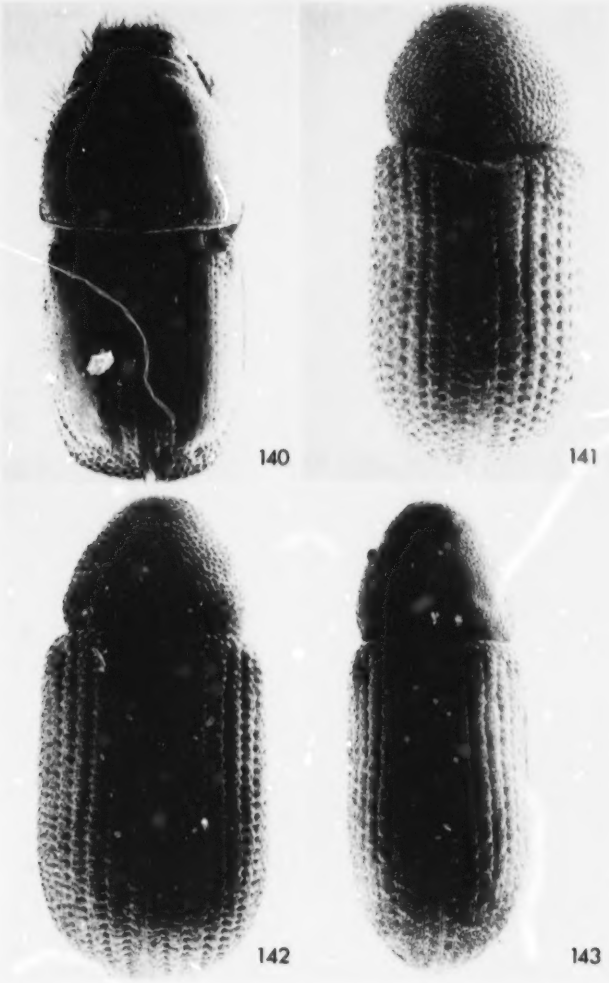
Figs. 118–125. Lateral views of various species. 118, *Polygraphus rufipennis;* 119, *Micracis swainei;* 120, *Trypophloeus striatulus;* 121, *Procryphalus utahensis;* 122, *Cryphalus ruficollis;* 123, *Crypturgus borealis;* 124, *Dolurgus pumilus;* 125, *Trypodendron lineatum.*



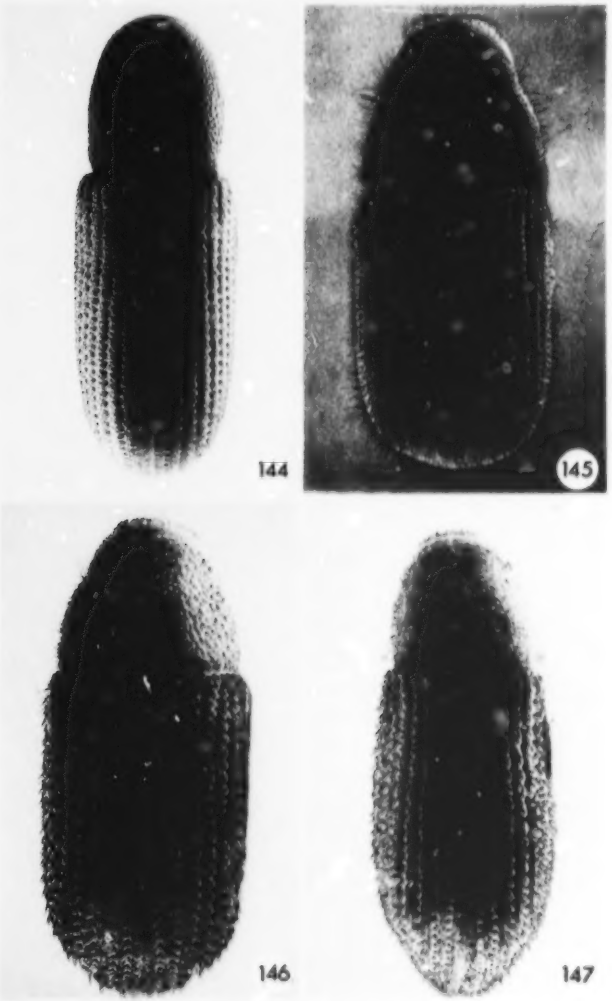
Figs. 126–133. Lateral views of various species. 126, *Xyloterinus politus;* 127, *Lymantor decipens;* 128, *Dryocoetes affaber;* 129, *Pityogenes plagiatus knechteli;* 130, *Pityokteines sparsus;* 131, *Orthotomicus caelatus;* 132, *Ips pini;* 133, *Xyleborus sayi.*



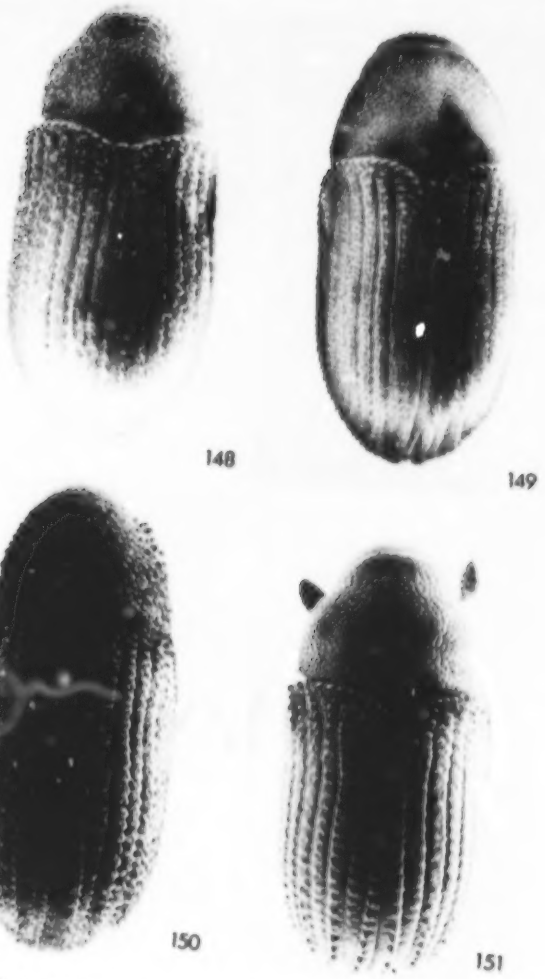
Figs. 134–139. Lateral views of various species. 134, *Conophthorus resinosae*; 135, *Gnathotrichus materiarius*; 136, *Pseudopityophthorus minutissimus*; 137, *Pityophthorus confinis*; 138, *Monarthrum mali*; 139, *Corthylus punctatissimus*.



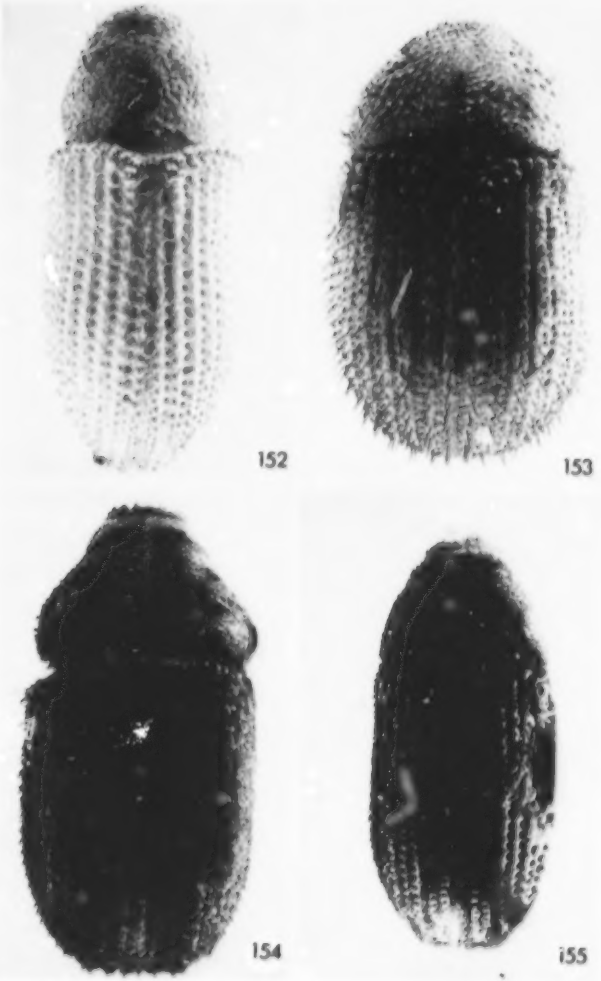
Figs. 140–143. Dorsal views of various species. 140, *Scolytus piceae*; 141, *Hylastinus obscurus*; 142, *Scierus annectans*; 143, *Hylurgops rugipennis*.



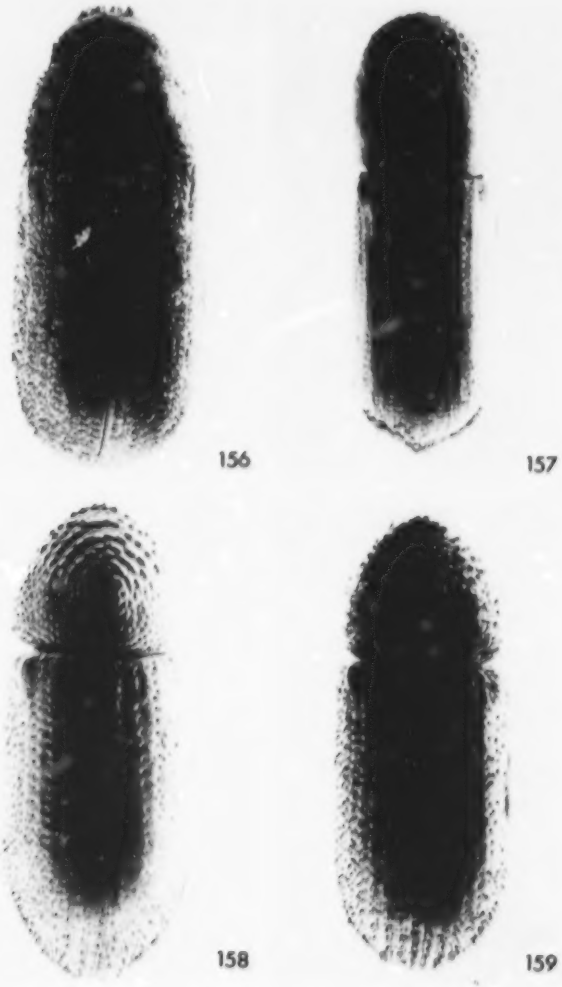
Figs. 144–147. Dorsal views of various species. 144, *Hylastes macer*; 145, *Dendroctonus ponderosae*; 146, *Hylurgopinus rufipes*; 147, *Xylechinus montanus*.



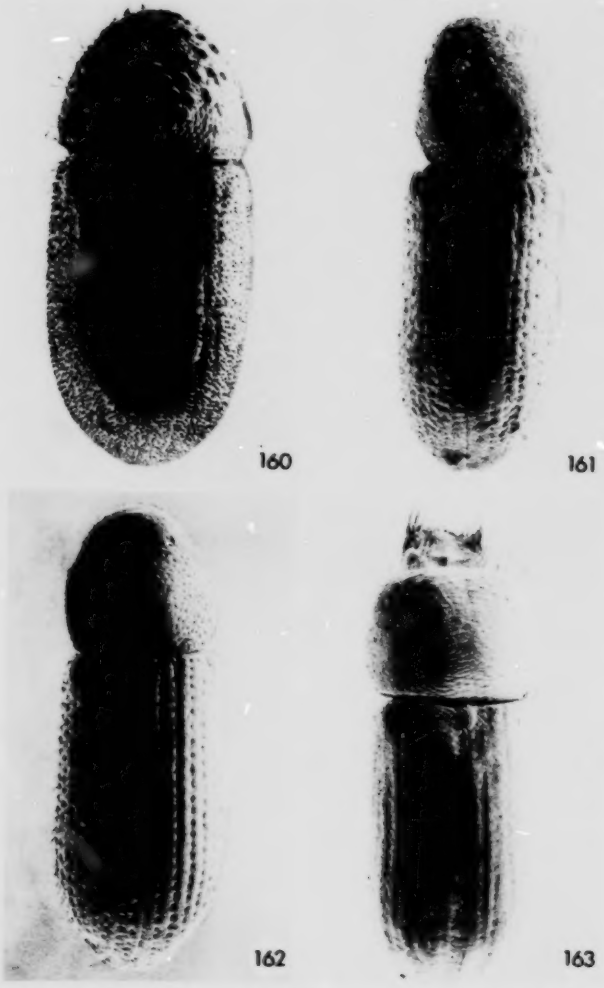
Figs. 148–151. Dorsal views of various species. 148, *Pseudohylesinus grandis*; 149, *Leperisinus aculeatus*; 150, *Alniphagus aspericollis*; 151, *Phloeosinus punctatus*.



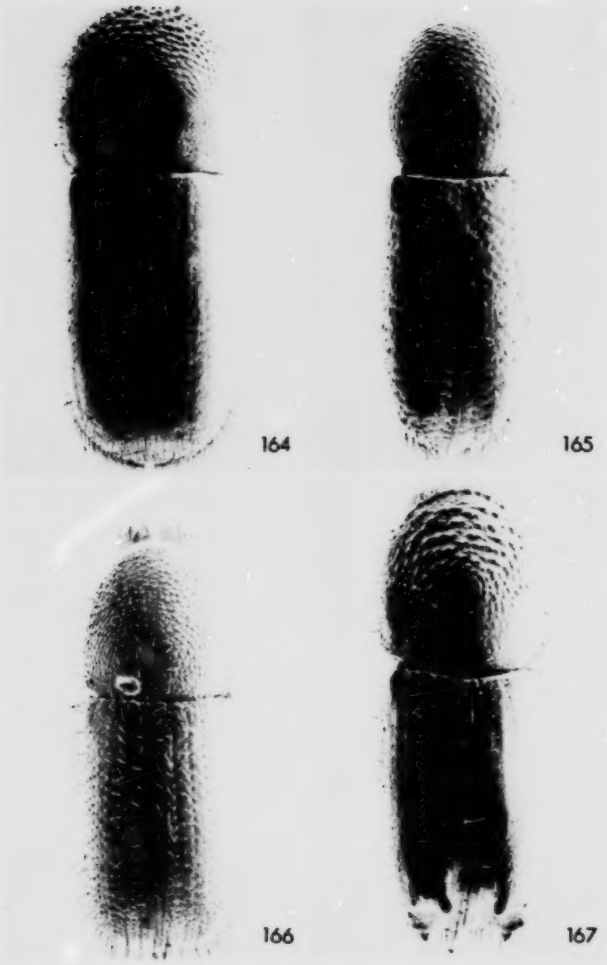
Figs. 152–155. Dorsal views of various species. 152, *Phloeotribus piceae*; 153, *Chramesus hicoriae*; 154, *Chaetophloeus heterodoxus*; 155, *Carphoborus carri*.



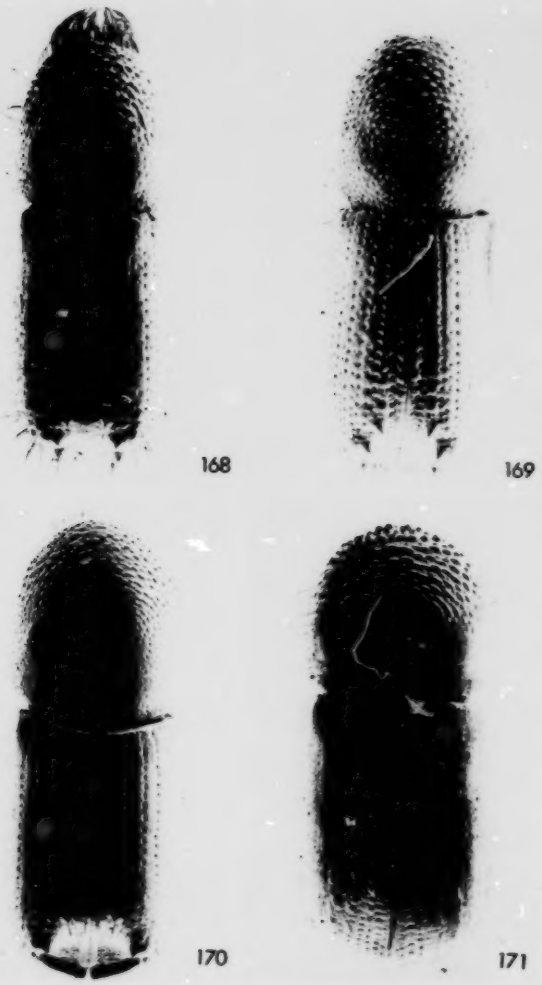
Figs. 156–159. Dorsal views of various species. 156, *Polygraphus rufipennis*; 157, *Micracis swainei*; 158, *Trypophloeus striatulus*; 159, *Procryphalus utahensis*.



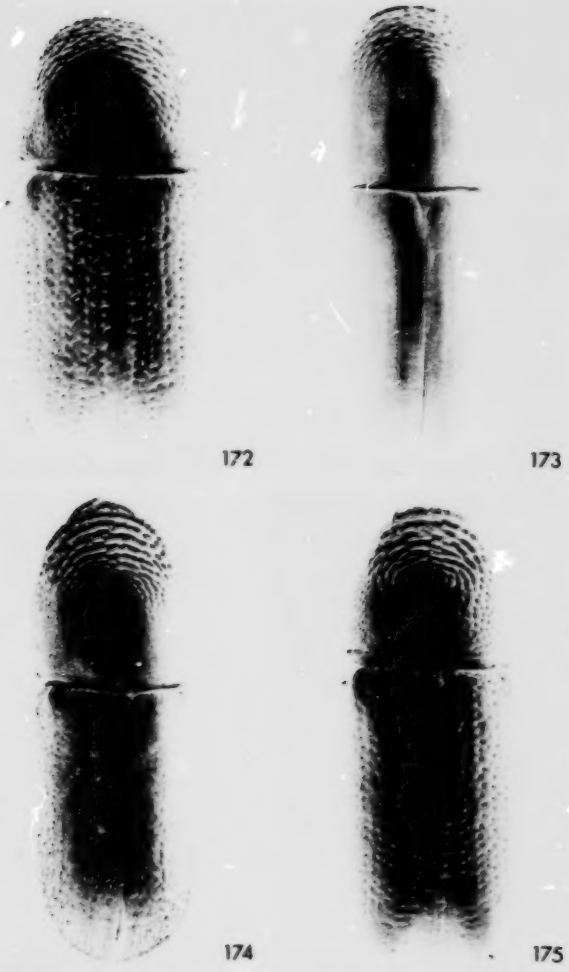
Figs. 160–163. Dorsal views of various species. 160, *Cryphalus ruficollis*; 161, *Crypturgus borealis*; 162, *Dolurgus pumilus*; 163, *Trypodendron betulae*.



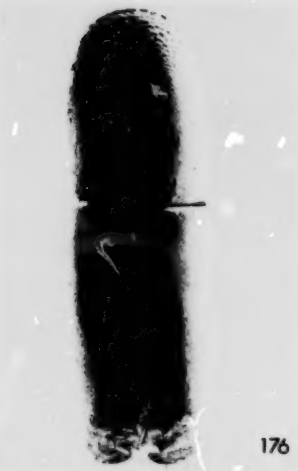
Figs. 164–167. Dorsal views of various species. 164, *Xyloterinus politus;* 165, *Lymantor decipens;* 166, *Dryocoetes affaber;* 167, *Pityogenes plagiatus knechteli.*



Figs. 168–171. Dorsal views of various species. 168, *Pityokteines sparsus*; 169, *Orthotomicus caelatus*; 170, *Ips pini*; 171, *Xyleborus savi*.



Figs. 172–175. Dorsal views of several species. 172, *Conophthorus resinosae*; 173, *Gnathotrichus materiarius*; 174, *Pseudopityophthorus minutissimus*; 175, *Pityophthorus confinis*.



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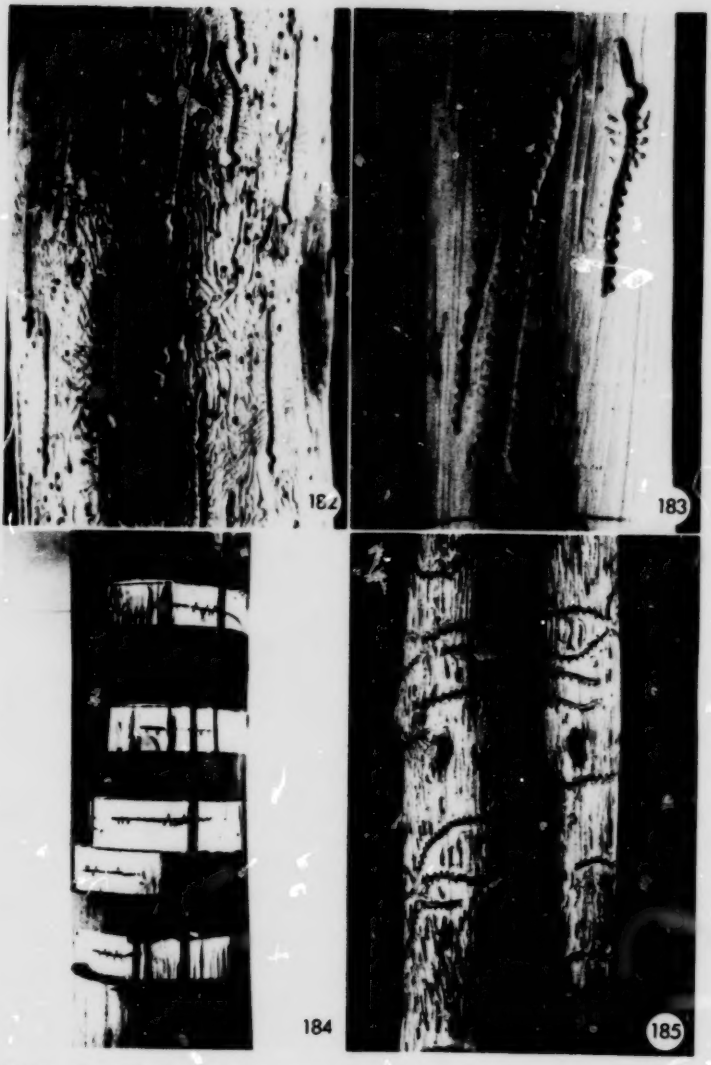
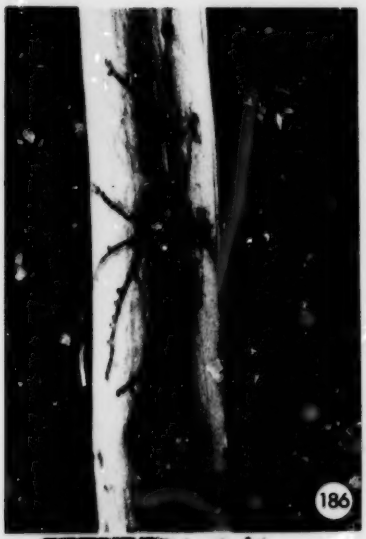
Figs. 176 and 177. Dorsal views of two species. 176, *Monarthrum mali*; 177, *Corthylus punctatissimus*.

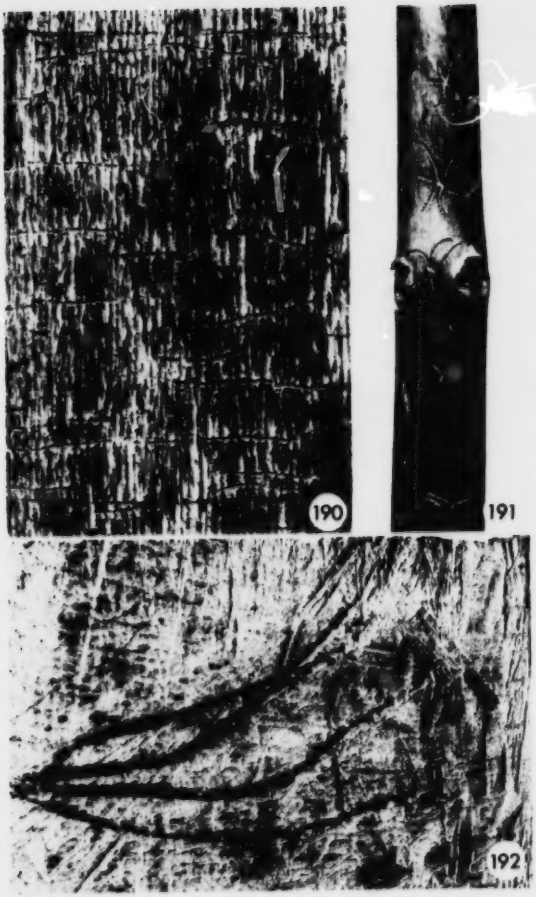
Figs. 178–181. Egg galleries of various species. 178, *Scolytus ventralis;* 179, *Dendroctonus brevicomis;* 180, *Polygraphus rufipennis;* 181, *Phloeosinus sequoiae.*



Figs. 182–185. Egg galleries of various species. 182, *Phloeosinus scopulorum*; 183, *P. hoferi*; 184, *Trypodendron lineatum*; 185, *Pityogenes hopkinsi*.



Figs. 186–189. Egg galleries of various species. 186, *Pityogenes plagiatus knechteli*; 187, *Ips concinnus*; 188, *I. pini*; 189, *Conophthorus* sp.



Figs. 190–192. Egg galleries of various species. 190, *Pseudopityophthorus pubipennis;* 191, *Pityophthorus pseudotsugae;* 192, *Monarthrum scutellare.*

Host Records

The following list of hosts is taken from the collection records held in my files. Plant names have been changed, when necessary, to conform with those used by Hosie (1969). No claim can be made as to the accuracy of these records, because the host plant may have been misidentified, but, in general, the records should be considered correct. Obvious misidentifications of the host have been omitted.

All species of bark beetle known or suspected to occur in Canada are included. An asterisk indicates that the species has been found on a particular host plant outside Canada and can be expected to be found on that host plant in Canada.

Host plants are listed in alphabetical order under either coniferous or broad-leaved species.

Coniferous species

Abies amabilis (Dougl.) Forbes
- *Gnathotrichus sulcatus*
- *Pseudohylesinus grandis*
- *P. granulatus*
- *P. nobilis*
- *P. tsugae*
- *Scolytus ventralis*
- *Trypodendron lineatum*

Abies balsamea (L.) Mill.
- *Cryphalus ruficollis*
- *Crypturgus pusillus*
- *Gnathotrichus materiarius*
- *Pityokteines minutus* (?)
- *P. sparsus*
- *Pityophthorus angustus**
- *P. balsameus**
- *P. cariniceps*
- *P. consimilis*
- *P. opaculus*
- *P. patchi*
- *P. puberulus*
- *P. pulchellus*
- *Polygraphus rufipennis*
- *Scolytus piceae**
- *S. unispinosus*
- *S. ventralis*
- *Trypodendron lineatum*

Abies grandis (Dougl.) Lindl.
- *Cryphalus pubescens**
- *C. ruficollis*
- *Gnathotrichus retusus**
- *G. sulcatus*
- *Pityokteines elegans*
- *P. minutus**
- *Pityophthorus nitidulus*
- *P. pseudotsugae*
- *Pseudohylesinus dispar dispar*
- *P. grandis*
- *P. granulatus*
- *Scolytus fiskei*
- *S. opacus abietis**
- *S. subscaber*
- *S. ventralis*
- *Trypodendron lineatum*

Abies lasiocarpa (Hook.) Nutt.
- *Cryphalus ruficollis*
- *Crypturgus borealis*
- *Dryocoetes confusus*
- *D. schelti*
- *Orthotomides lasiocarpa*
- *Pityokteines elegans*
- *P. minutus*
- *Pityophthorus demissus**
- *P. occidentalis*
- *Scierus annectans*
- *S. pubescens*
- *Scolytus opacus opacus**
- *S. piceae*
- *Trypodendron lineatum*
- *Xylechinus montanus*

Abies spp.
- *Dryocoetes affaber*
- *Hylastes nigrinus*
- *H. gracilis*
- *Hylurgops rugipennis*
- *Phloeotribus lecontei*
- *Pseudohylesinus dispar pullatus**
- *Scolytus tsugae*

Chamaecyparis nootkatensis (D. Don) Spach
- *Phloeosinus cupressi*
- *P. keeni*
- *P. punctatus*

Juniperus scopulorum Sarg.
- *Phloeosinus hoferi*
- *P. hoppingi*
- *P. scopulorum*
- *P. serratus*

Juniperus virginiana L.
- *Phloeosinus canadensis*

Larix laricina (Du Roi) K. Koch
- *Dendroctonus pseudotsugae*
- *D. punctatus*
- *D. simplex*
- *D. valens**
- *Dryocoetes affaber*
- *D. autographus*
- *Hylurgops pinifex*
- *Orthotomicus caelatus*
- *Orthotomides lasiocarpa*
- *Polygraphus rufipennis*
- *Scolytus laricis*
- *S. piceae*
- *S. tsugae*
- *Trypodendron lineatum*

Larix lyallii Parl.
- *Pityophthorus alpinensis*
- *Scolytus laricis**

Larix occidentalis Nutt.
- *Dendroctonus pseudotsugae**
- *Orthotomicus caelatus*
- *Scolytus laricis*
- *S. unispinosus*
- *Xylechinus montanus*

Picea engelmannii Parry
- *Carphoborus intermedius**
- *Crypturgus borealis*
- *Dendroctonus murrayanae*
- *D. rufipennis*
- *Dryocoetes affaber*
- *D. autographus*
- *D. confusus*
- *Gnathotrichus retusus*
- *Hylastes macer*
- *H. nigrinus*
- *Hylurgops porosus*
- *Ips borealis*
- *I. perturbatus*
- *I. tridens*
- *Orthotomicus caelatus*
- *Orthotomides lasiocarpa*
- *Phloeotribus lecontei*
- *Pityogenes fossifrons**
- *Pityophthorus albertensis*
- *P. intextus*
- *P. occidentalis*
- *P. nitidulus*
- *Polygraphus rufipennis*
- *Scierus annectans*
- *S. pubescens*
- *Scolytus piceae*
- *Trypodendron lineatum*
- *T. rufitarsus*
- *Xylechinus montanus*

Picea glauca (Moench) Voss
- *Carphoborus andersoni*
- *C. carri*
- *C. sansoni*
- *Cryphalus ruficollis*
- *Crypturgus borealis*
- *C. pusillus*
- *Dendroctonus murrayanae*

D. punctatus
D. rufipennis
D. valens
Dryocoetes affaber
D. autographus
D. caryi
Gnathotrichus materiarius
Hylastes porculus
Hylurgops pinifex
H. rugipennis
Ips borealis
I. latidens
I. perturbatus
I. tridens
Orthotomicus caelatus
Phloeosinus pini
Phloeotribus piceae
Pityogenes hopkinsi
Pityophthorus albertensis
P. borealis
P. intextus
P. nitidulus
P. shepardi
P. watsoni
Polygraphus rufipennis
Scierus annectans
S. pubescens
Scolytus piceae
S. tsugae
Trypodendron lineatum
T. rufitarsus
Xylechinus americanus
X. montanus

Picea mariana (Mill.) B.S.P.
Carphoborus andersoni
Cryphalus ruficollis
Crypturgus borealis
Dendroctonus rufipennis
Dryocoetes affaber
D. autographus
Hylurgops pinifex
Ips borealis
I. latidens
I. perturbatus
I. tridens
Orthotomicus caelatus
Phloeosinus pini
Pityogenes plagiatus plagiatus
Pityophthorus borealis
P. intextus
P. nitidulus
P. shepardi
P. watsoni
Polygraphus rufipennis
Scierus annectans
Scolytus piceae
Trypodendron lineatum

Picea rubens Sarg.
Carphoborus carri
C. dunni
Crypturgus borealis
Dendroctonus punctatus
Dryocoetes affaber
*D. caryi**
Orthotomicus caelatus
*Pityophthorus angustus**
*P. biovalis**
*P. briscoli**
*P. cascoensis**
*P. dentifrons**
P. shepardi
P. watsoni
Polygraphus rufipennis
Scolytus piceae
Trypodendron lineatum

Picea sitchensis (Bong.) Carr.
*Cryphalus pubescens**
Crypturgus borealis
Dendroctonus punctatus
D. rufipennis
Dryocoetes affaber
D. autographus
Gnathotrichus retusus
*Hylastes nigrinus**
Hylurgops rugipennis
Ips concinnus
I. tridens
*Orthotomicus caelatus**
Pityophthorus nitidulus
Polygraphus rufipennis
Pseudohylesinus grandis
P. nebulosus nebulosus
P. sitchensis
Scierus pubescens
Scolytus piceae
Trypodendron lineatum

Picea spp.
Dendroctonus valens
Pityophthorus borealis
P. concavus
P. consimilis
P. mundus
P. nitidus
P. opaculus

P. patchi
P. puberulus
P. pulchellus
P. tonsus
Polygraphus convexifrons
Scolytus ventralis
Trypodendron retusum

Pinus albicaulis Engelm.
*Dendroctonus ponderosae**
*Ips latidens**
*Pityogenes fossifrons**
Pityophthorus collinus
*P. confertus**
*P. confinus**
*P. murrayanae**
P. opimus
P. toralis

Pinus banksiana Lamb.
Carphoborus carri
Conophthorus banksiana
C. coniperda
C. resinosae
Dendroctonus murrayanae
D. valens
Gnathotrichus materiarius
Hylastes porculus
Hylurgops pinifex
Ips calligraphus
I. grandicollis
I. perroti
I. perturbatus
I. pini
Orthotomicus caelatus
Phloeosinus pini
Pityogenes hopkinsi
P. plagiatus plagiatus
Pityophthorus intextus
P. opaculus
P. patchi
P. puberulus
P. publicarius
P. pulchellus
Polygraphus rufipennis
Trypodendron lineatum
T. rufitarsus

Pinus contorta Dougl.
(including var. *latifolia* Engelm.)
*Carphoborus intermedius**
C. ponderosae
*Conophthorus contortae**
Dendroctonus murrayanae
D. ponderosae
*D. valens**
Dolurgus pumilus
Gnathotrichus retusus
G. sulcatus
Hylastes longicollis
Hylurgops porosus
H. reticulatus
H. rugipennis
H. subcostulatus
Ips emarginatus
I. integer
I. latidens
I. mexicanus
I. montanus
I. perroti
I. perturbatus
I. pini
I. plastographus plastographus
I. tridens
Myeloborus boycei
Orthotomicus caelatus
Pityogenes fossifrons
P. plagiatus knechteli
Pityokteines elegans
P. ornatus
Pityophthorus albertensis
P. aplanatus
P. confertus
*P. fuscus**
*P. gracilis**
*P. idoneus**
P. murrayanae
P. nitidulus
P. nitidus
P. opimus
*P. scalptor**
P. smithi
P. toralis
P. tuberculatus
Polygraphus convexifrons
P. rufipennis
Pseudohylesinus sericeus
Scierus annectans
S. pubescens
Scolytus piceae
Trypodendron lineatum
T. rufitarsus

Pinus flexilis James
Carphoborus carri
*Conophthorus flexilis**
*Dendroctonus ponderosae**
*Ips latidens**

I. woodi
*Pityogenes carinulatus**
*P. fossifrons**
Pityophthorus albertensis
*P. confertus**
*P. murrayanae**
P. opimus
P. toralis
*P. tuberculatus**

Pinus monticola Dougl.
Conophthorus monticolae
Crypturgus borealis
Dendroctonus ponderosae
*D. valens**
Hylurgops porosus
H. rugipennis
*H. subcostulatus**
*Ips emarginatus**
*I. latidens**
I. montanus
Orthotomicus caelatus
Pityogenes carinulatus
P. fossifrons
*Pityophthorus confertus**
*P. murrayanae**
*P. tuberculatus**
*Trypodendron lineatum**
Xylechinus montanus

Pinus ponderosa Laws.
*Carphoborus ponderosae**
Conophthorus ponderosae
Dendroctonus brevicomis
D. ponderosae
D. valens
*Dryocoetes autographus**
Gnathotrichus retusus
Hylastes longicollis
H. nigrinus
H. ruber
Hylurgops porosus
H. reticulatus
H. rugipennis
H. subcostulatus
Ips emarginatus
I. integer
I. latidens
*I. mexicanus**
I. pini
I. tridens
Myeloborus boycei
Pityogenes carinulatus
P. fossifrons
Pityokteines ornatus
Pityophthorus confertus
P. confinus
P. cutleri
P. grandis
P. idoneus
P. scalptor
P. tuberculatus
Trypodendron rufitarsus

Pinus resinosa Ait.
Conophthorus banksiana
C. coniperda
C. resinosae
Cryphalus ruficollis
Dendroctonus murrayanae
D. valens
Gnathotrichus materiarius
Hylastes porculus
Hylurgops pinifex
Ips calligraphus
I. grandicollis
I. perroti
I. pini
*Myeloborus fivazi**
Orthotomicus caelatus
Pityogenes hopkinsi
P. plagiatus plagiatus
Pityophthorus cariniceps
*P. concavus**
P. consimilis
P. mundus
P. opaculus
P. patchi
P. puberulus
P. pulchellus
P. pulicarius
*P. tonsus**
Polygraphus rufipennis
Scolytus piceae
Trypodendron lineatum

Pinus strobus L.
Conophthorus coniperda
Cryphalus pusillus
*Dendroctonus valens**
Gnathotrichus materiarius
Hylastes porculus

Hylurgops pinifex
Ips calligraphus
I. latidens
I. pini
Myeloborus ramiperda
Orthotomicus caelatus
Pityogenes hopkinsi
*Pityophthorus angustus**
P. cariniceps
P. consimilis
P. mundus
P. opaculus
P. patchi
P. puberulus
P. pulchellus
P. pulicarius
Polygraphus rufipennis
Trypodendron lineatum

Pinus spp.
*Dyrocoetes granicollis**
Hylastes gracilis
H. macer
Phloeosinus pini
*Xyleborus ferrugineus**
X. saxeseni
*Xylechinus americanus**

Pseudotsuga menziesii (Mirb.) Franco
Carphoborus vandykei
Cryphalus pubescens
C. ruficollis
Dendroctonus pseudotsugae
Dryocoetes autographus
Gnathotrichus retusus
G. sulcatus
Hylastes macer
H. nigrinus
H. ruber
H. tenuis
Hylurgops porosus
H. reticulatus
H. rugipennis
Ips latidens
Phloeotribus lecontei
Pityokteines minutus
Pityophthorus confertus
P. nitidulus
P. orarius
P. pseudotsugae
Polygraphus convexifrons
P. rufipennis
Pseudohylesinus grandis
P. nebulosus nebulosus
P. tsugae
Scolytus fiskei
*S. opacus opacus**
*S. oregoni**
S. tsugae
S. unispinosus
S. ventralis
Trypodendron lineatum
T. rufitarsus

Thuja occidentalis L.
Phloeosinus canadensis

Thuja plicata Donn
Phloeosinus cupressi
P. punctatus
P. sequoiae
Trypodendron lineatum

Tsuga canadensis (L.) Carr.
Ips latidens

Tsuga heterophylla (Raf.) Sarg.
Dendroctonus pseudotsugae
Gnathotrichus retusus
G. sulcatus
Hylastes nigrinus
Hylurgops porosus
H. reticulatus
H. rugipennis
Pityogenes fossifrons
Pseudohylesinus grandis
P. granulatus
P. nebulosus nebulosus
P. tsugae
Polygraphus rufipennis
Scolytus tsugae
S. unispinosus
S. ventralis
Trypodendron lineatum
*Xyleborus saxeseni**

Tsuga mertensiana (Bong.) Carr.
Pseudohylesinus tsugae
Scolytus tsugae
*S. unispinosus**

Broad-leaved species

Acer spp.
- *Corthylus columbianus*
- *C. punctissimus*
- *Hylocurus rudis**
- *Lymantor decipens*
- *Monarthrum mali*
- *Pityophthorus rhois*
- *Xyleborus dispar*
- *X. obesus*
- *X. saxeseni*
- *Xyloterinus politus*

Alnus spp.
- *Alniphagus aspericollis*
- *A. hirsutus*
- *Gnathotrichus retusus*
- *Hylocurus hirtellus**
- *Trypodendron betulae*
- *T. lineatum*
- *Trypophloeus salicis*
- *T. striatulus*
- *Xyleborus saxeseni*
- *X. sayi*
- *Xyloterinus politus*

Betula spp.
- *Dryocoetes betulae*
- *Monarthrum mali*
- *Pseudopityophthorus asperulus**
- *Trypodendron betulae*
- *T. lineatum*
- *Xyleborus sayi*
- *Xyloterinus politus*

Carya spp.
- *Chramesus hicoriae*
- *Scolytus quadrispinosus*
- *Thysanoes fimbricornis**
- *Xyleborus celsus**

Castanea dentata (Marsh.) Borkh.
- *Hylocurus rudis**
- *Pseudopityophthorus asperulus**

Ceanothus spp.
- *Chaetophloeus heterodoxus*

Celtis spp.
- *Scolytus muticus*

Cercis canadensis L.
- *Micracis suturalis**

Corylus spp.
- *Corthylus punctatissimus*

Crataegus spp.
- *Scolytus rugulosus*

Fagus spp.
- *Corthylus punctatissimus*
- *Monarthrum fasciatum*
- *Xyleborus pubescens**
- *Xyloterinus politus*

Fraxinus spp.
- *Hylurgopinus rufipes*
- *Leperisinus aculeatus*
- *L. californicus*
- *L. criddlei*

Hicoria spp.
- *Chramesus hicoriae*
- *Hylocurus biorbis**
- *H. rudis**
- *Monarthrum fasciatum*
- *Thysanoes fimbricornis**

Juglans spp.
- *Micracis suturalis**
- *Monarthrum mali*

Malus spp.
- *Chaetophloeus heterodoxus*
- *Scolytus mali*
- *Xyleborus dispar*

Populus tremuloides Michx.
- *Procryphalus mucronatus*
- *Trypodendron retusum*
- *Trypophloeus populi*
- *T. thatcheri*

Populus spp.
- *Micracis swainei*
- *Trypophloeus salicis*
- *Xyleborus dispar*
- *X. saxeseni*

Prunus spp.
- *Chaetophloeus heterodoxus*
- *Hylurgopinus rufipes*
- *Phloeotribus liminaris*
- *Scolytus rugulosus*
- *Xyleborus dispar*

Pyrus spp.
- *Chaetophloeus heterodoxus*
- *Scolytus mali*

Quercus spp.
- *Monarthrum fasciatum*
- *M. mali*
- *M. scutellare*
- *Pseudopityophthorus asperulus**
- *P. minutissimus*
- *P. pruinosus**
- *P. pubipennis*
- *Thysanoes fimbricornis**
- *Xyleborus pubescens**
- *X. saxeseni*
- *X. xylographus*

Rhus spp.
- *Pityophthorus rhois*

Salix spp.
- *Hylocurus hirtellus**
- *Lymantor decipens*
- *Micracis swainei*
- *Procryphalus utahensis*
- *Trypophloeus salicis*
- *T. striatulus*

Sorbus spp.
- *Scolytus mali*

Tilia americana L.
- *Pseudothysanoes rigidus**

Ulmus americana L.
- *Hylurgopinus rufipes*
- *Monarthrum mali*
- *Scolytus mali*
- *S. multistriatus*
- *Xyleborinus politus*

Glossary

Aciculate: refers to a surface bearing minute subparallel scratches closely resembling those made with the point of a needle.
Acuminate: tapering to an acute point.
Acute: pointed; ending in or forming less than a right angle.
Apex: the part of a joint or segment that is opposite the base by which it is attached; of the elytra, the caudal portion; of the pronotum, the cephalic portion; of the antennal club, the distal portion.
Approximate: situated close together.
Arcuate: arched; bowlike.
Armature: the chitinous teeth, processes, or coarse sculpturing.
Asperate: having the surface finely or moderately roughened with acute or subacute elevations.
Asperities: small or moderate surface roughenings, especially when acute; from coarse granules to rather prominent elevations; especially the lunular elevations on the anterior portion of the pronotum.

Base: the part of any appendage or structure that is nearest the body; of the pronotum, the caudal portion; of the elytra, the cephalic portion; of the antennal club, the proximal portion.
Bilobed: divided into two lobes.
Bisinuate: having two sinuations or incisions.
Bisulcate: having two parallel grooves.
Bristle: a short, stiff hair.

Capitate: refers to a structure in which the distal portion is swollen forming a subglobular mass.
Carina: a narrow ridge or keel.
Carinate: keeled; having a carina or keel.
Clavate: club-shaped.
Club: the enlarged terminal part of the antennae.
Compressed: flattened from side to side.
Confusedly: irregularly; of punctures or pubescence, not in regular rows.
Contiguous: touching when in normal position.
Coxa, coxae: the basal segment of the leg, by which it is attached to the body.
Crenulate: applied to a margin forming a wavy line with small, regular, and deep curves.
Crenulations: small, rounded surface projections, especially on the elytral base or interspaces; rounded teeth.
Concavity: a broad impression or excavation, larger than a fovea; e.g., the declivital concavity in the genus *Ips*, and the frontal concavity in the males of *Trypodendron*.
Costal: of elytra, the lateral margin.

Declivitous: sloping rather steeply downwards.
Declivity: the usually steep posterior face of the elytra, or the steeply sloping anterior face of the pronotum.
Declivous: sloping gradually downwards.
Disk: the central portion of any surface; of elytra, the dorsal portion extending laterally from the suture to about the fourth striae.
Distal: applied to the portion of an appendage farthest from the body.
Dorsal: of or pertaining to the upper surface.

Egg galleries: galleries constructed by an adult female for the purpose of laying eggs.
Elytra: the chitinous wings of beetles, serving as coverings of the hind wings, usually meeting in a straight line down the dorsum.
Elytral interspaces: the space between the elytral striae.
Elytral striae: a longitudinal line of punctures, extending from the base to the apex of the elytra.
Elytral suture: the longitudinal line on the dorsum marking the junction of the elytra.
Emarginate: with a notch cut from the margin.
Emargination: a broad or narrow angular or rounded notch breaking the margin.
Epistoma: the lower portion of the front of the head between the eyes and the mouth cavity; the reduced frontoclypeal region.
Epistomal lobe: a flat depressed lobe directed over the base of the mandibles from the median portion of the epistomal margin.
Epistomal margin: the dorsal margin of the mouth cavity.
Epistomal process: a flattened dorsal prominence with converging or parallel sides arising from the base of the epistoma with its apex reaching toward or to the epistomal margin.

Face: the outer surface of any part.
Fovea: a small, well-defined impression.
Frass: a sawdustlike material composed of boring dust and excrement produced by the beetle boring in the host plant.
Frons: the front part of the head extending from the epistoma to the upper level of the eyes.
Front: the dorsal face of the head between the vertex and the epistomal margin; synonymous with frons.
Frontal: pertaining to the front or the frons.
Funicle: the portion of the antennae between the first segment (or scape) and the club, composed of from one to seven segments in the ipid beetles.

Glabrous: smooth, without vestiture of any kind.
Granulate: having small granules on the surface.
Granules: fine, acute, or blunt grainlike prominences on a surface.
Gula: the throat sclerite forming the central part of the head beneath, next to the posterior tentorial pits, extending from the submentum to the posterior margin, and laterally bounded by the genae.

Hair: a slender, threadlike filament.
Hirsute: covered with long, coarse hairs.

Insertion: the place of attachment of an appendage.
Interspace: the area between two elytral striae.
Interstria, interstriae: a secondary row of punctures along the median line of an interspace, sometimes bearing setae, granules, or punctures.
Interstrial: pertaining to the interstriae.

Lamellate: composed of closely placed, thin, platelike processes; applied to the antennal club of *Phloeotribus*, in which the segments of the club are laterally produced, although not truly platelike.

Margin: the portion of a segment adjoining the edge.
Marginal: pertaining to the margin; near the edge.
Margined: bounded by a finely elevated marginal line.
Median lobe: see epistomal lobe.
Meso-: middle, belonging to the mesothorax.
Mesothorax: the middle segment of the thorax.
Meta-: posterior, belonging to the metathorax.
Metacoxa: the coxa on the metathorax.
Metathorax: the third or posterior segment of the thorax.
Monogamy: having one mate only; condition where a female is fertilized by one male only.
Mucro: a long, pointed process.

Obliquely truncate: applied to antennal club, the distal portion of the outer face slanting toward the apex.
Opaque: dull, applied to a surface without luster.

Parent galleries: galleries constructed by the original attacking parents; see egg galleries.
Pedicle: the first joint of the antennal funicle, attached to the scape.
Pilose: covered with very fine hairs.
Pitch tubes: a cylinder of resin surrounding the entrance hole.
Plumose: having feathers or plumes.
Polygamy: the condition of having more than one mate at one time.
Pregula: a small triangular sclerite on the ventral portion of the head just posterior to the oral opening formed by the divergence of the arms of the gular suture.
Pro-: anterior; used as prefix meaning before, or in front of, or the first segment of the thorax, as prothorax, prosternum, or pronotum.
Process: a prolongation of any part of the surface without an articulation.
Procurved: arcuate with the convexity in front.
Produced: drawn out into a protuberance or a prolongation.
Pronotum: the dorsal piece of the prothorax.
Prosternal piece: the median, caudal, intercoxal extension of the prosternum.
Prothorax: the first segment of the thorax.

Pubescence: a covering of short, soft, fine hair; sometimes used to describe the covering of an insect's body.
Pubescent: densely or sparsely covered with fine hair.
Punctate: bearing punctures.
Punctures: a small impression on the surface of the body, like that made by a needle.
Punctured: marked with small impressed points or punctures.
Punctate-granulate: with punctures and granules intermixed.
Punctate-striate: with punctured striae.

Recumbent: reclining, not erect, applied to hair or scales.
Recurved: arcuate with the convexity behind.
Reticulate: marked with a network of fine impressed or elevated lines.
Rostrate: having a rostrum, a short projection bearing the mouthparts.
Rostrum: the beak or snoutlike extension of the front of the head.
Rugose: wrinkled, marked with coarse elevations.
Rugosities: moderate to coarse surface wrinkles or strong, blunt elevations; synonymous with coarse and blunt asperities.
Rugulose: finely rugose.

Scabrous: rough with numerous small elevations.
Scale: a broad, flattened unicellular outgrowth of the body wall, of various shapes and sizes.
Scape: the elongate first segment of the geniculate antennae.
Sclerite: a piece of the body wall bounded by sutures.
Sculpture: the elevated or impressed markings on the surface of the body.
Scutellum: the subtriangular piece between the bases of the elytra.
Septate: divided by an internal partition or septum.
Serrate: armed with a row of close-set teeth, as a saw.
Serration: a small tooth, as of a saw.
Seta, setae: a rather short, stiff, pointed hair.
Setose: having setae.
Sinuate: undulating
Solid: applied to an antennal club of apparently only one segment.
Spatulate: narrow and flat at the base and enlarged at the apex; shaped like a spatula.
Spine: an elongate, acute process.
Spinose: having spines.
Sternite: the ventral piece or sclerite of a body segment.
Stria, striae: a narrow, impressed line, usually longitudinal, especially the parallel impressed, usually punctured, lines on the elytra from base to apex.
Striate: having striae.
Sub-: slightly less than the meaning of the word it is attached to as a prefix.
Sulcate: marked with a broad furrow or with parallel grooves.
Summit: applied to the pronotum, the highest part on the dorsal surface; applied to the declivity, the portion at the beginning of the slope, the highest part.
Sutural interspace: the first interspace or the one on each side of the suture.
Sutural stria: the first stria or the one on each side of the suture.
Suture: the longitudinal line on the dorsum marking the junction of the elytra.

Tooth: a short, acute process, often conical.
Truncate: cut off squarely at the tip.
Tubercle: a small or moderate knoblike prominence, a coarse granule or small blunt tooth.
Tuberculate: having tubercles.

Uniseriate: arranged in a single row.

Venter: the lower surface of the abdomen.
Ventral: pertaining to the venter.
Vertex: the top of the insect head between the eyes, front, and occiput.
Vestiture: all the surface covering, including all hairs, scales, and setae.

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